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HYBRIDIZATION OF *PUCCINIA GRAMINIS TRITICI* WITH *PUCCINIA GRAMINIS SECALIS* AND *PUCCINIA GRAMINIS AGROSTIDIS*[1]

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Hybridization of the physiologic forms of *Puccinia graminis tritici* Erikss. and Henn., has recently been demonstrated by Waterhouse (*9*) and by the present writers (*5, 6*). It now seems clear that new physiologic forms of wheat stem rust can and do originate from crosses between existing forms. Furthermore, evidence has been advanced by Stakman, Levine, and Cotter (*8*) and by Levine and Cotter (*4*) to show that hybridization is possible between the *tritici* and *secalis* races[3] of *Puccinia graminis* Pers. as well as between the *tritici* and *agrostidis* races. Similar evidence, with respect to the hybridizing ability of *P. graminis tritici* and *P. graminis secalis* Erikss. and Henn., has also been advanced by the present authors in a preliminary paper (*7*) embodying some of the results reported in greater detail in the present paper.

The investigation here described was undertaken to determine whether or not hybridization between certain of the physiologic races of *Puccinia graminis* could be accomplished by employing the methods previously used in crossing physiologic forms of *Puccinia graminis tritici.* The authors were particularly desirous of determining the ability of *Puccinia graminis tritici* to hybridize with the other physiologic races of *Puccinia graminis.* For this purpose, telia of three other physiologic races were secured, namely, *P. graminis avenae* Erikss. and Henn., *P. graminis secalis,* and *P. graminis agrostidis* Erikss. If positive results were secured from crosses between these races and *P. graminis tritici,* it was further desired to make a study of the first-generation hybrids[4] in order to ascertain their infection capabilities on graminaceous hosts. In this manner the writers hoped to determine the importance, if any, of inter-racial crosses in the origination of new strains of *Puccinia graminis.*

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3 The term "physiologic race" is here used—as adopted by J. C. Arthur in his "Plant Rusts"—to designate the original biological forms of *Puccinia graminis,* as established by Eriksson, namely, *P. graminis tritici, P. graminis secalis, P. graminis avenae,* etc. The term "race" has been selected in preference to the term "variety" as the latter term has been frequently employed in this paper with reference to cereals.

4 For the sake of convenience the term "hybrid" is used to denote any association of genotypes accomplished by means of crosses between physiologic forms or physiologic races of stem rust. While realizing that the validity of the term, when used in this sense, is open to argument, the authors have preferred to use it rather than to coin a new term for the designation of the above-mentioned genotypic associations.

The present paper deals with crosses of the *tritici* race with the *secalis* and the *agrostidis* race. The few attempts to cross *P. graminis tritici* and *P. graminis avenae* failed to produce any conclusive results as to the hybridizing ability of these two races, and so will not be discussed.

There is some reason for supposing that crosses between *P. graminis secalis* and *P. graminis tritici* might be more successful than other inter-racial crosses. Both races have in common the capacity of attacking barley and certain grass hosts. This similarity in parasitism is perhaps indicative of the close relationship of these rusts to each other. A comparison of the host ranges of the *agrostidis* and *secalis* races with that of the *tritici* race indicates that, of these two races, the *agrostidis* is parasitically, and hence physiologically, the farther removed from the *tritici* race. The *agrostidis* race lacks the power of attacking cultivated barley or other *Hordeum* species, and in nature is confined to *Agrostis* species and other grass hosts which are not attacked by the *tritici* race. From this consideration it seems natural to surmise that *agrostidis-tritici* hybrids might be more difficult to obtain than *secalis-tritici* hybrids.

Hybridization Between Puccinia graminis tritici and Puccinia graminis secalis

MATERIALS AND METHODS

The teliospores of the rye stem rust used in the crosses were collected at Ottawa, Ontario, by Mr. I. L. Conners, in March, 1930, on *Agropyron repens.* The teliospores germinated early in April and barberries were infected. Rye seedlings which were infected by the aeciospores proved susceptible, thus establishing the identity of the rust as *Puccinia graminis secalis.*

Two physiologic forms of wheat stem rust, namely, form 30 and form 95, were crossed with the rye stem rust. The culture of form 30 used in these experiments originated from a cross between forms 17 and 49, which has previously been described by the writers (*5*). This form is known to be heterozygous for pathogenicity (Table 1). Form 95 had its origin in aecia which resulted from a selfing of physiologic form 53.

The technique of crossing is based on the discovery of Craigie (*1, 2, 3*) relative to the function of the pycnium. As is well known, a teliospore, on germinating, produces four sporidia, two of one sex and two of an opposite sex. Each of these sporidia is capable of infecting the barberry and producing a pustule, which, of course, is in the haploid condition and contains pycniospores of the same sex as the sporidium causing the infection. Each haploid pustule produces an abundance of pycnial nectar which contains numerous pycniospores. By transferring this nectar from a haploid pustule of one sex to a haploid pustule of the opposite sex, it is possible to initiate the formation of diploid or dikaryotic aeciospores. When pycnial nectar of a haploid pustule arising from one physiologic form is transferred to a haploid pustule of the opposite sex arising from another physiologic form with the result that aecia are formed, it is considered that a cross has been made between the two physiologic forms.

In theory, the crossing of physiologic forms is a simple matter; in practice, there are various sources of error. One of the greatest of these is the difficulty of determining which pustules are haploid. In this work it has been assumed that isolated pustules which failed to develop aecia within about 20 days following infection were haploid. In addition there is always the possibility that pycnial nectar may be transferred from pustule to pustule by insects, although perhaps this is a less important source of error, as insects can be controlled without great difficulty.

In the manner already described, wheat stem rust was crossed with rye stem rust. The aecia which resulted from the crosses were picked off singly and transferred to Little Club wheat seedlings and to rye seedlings. The mono-aecial cultures thus established were then studied for pathogenicity on wheat and rye.

SELFING OF THE PARENT FORMS

A study was made of the breeding behaviour of each of the parent forms in order that a comparison might be made of the progeny of each form, when selfed, with its progeny when crossed with another form. All the progeny derived from selfing the rye stem rust was identified as rye stem rust. The progeny derived from selfing form 30 and form 95 of the wheat stem rust was resolved into characteristic physiologic forms of wheat stem rust (*vide* Table 1).

TABLE 1.—*The breeding behaviour of the parent forms used in the tritici-secalis crosses, as determined by selfing each form.*

Physiologic form used as parent	Forms isolated with number of cultures of each in parenthesis	Number of forms isolated	Conclusions respecting breeding behaviour
P. graminis tritici form 30	9 (1); 15 (3); 30 (5)	3	heterozygous
P. graminis tritici form 95	14 (2); 36 (1); 83 (1); 94 (1); 95 (3); 96 (3); 107 (1)	7	heterozygous
P. graminis secalis	*P. graminis secalis*	–	—

INTERFERTILITY OF THE TRITICI AND SECALIS RACES

Although there is no doubt concerning the interfertility of these two physiologic races, there is some question as to whether their interfertility is as complete as that between the different physiologic forms of the *tritici* race. No special experiments were made to decide this point; but the data accumulated in the crosses here reported and in preliminary crossing experiments suggest that the interfertility of these two physiologic races is quite high and perhaps complete. The fact that approximately one-half of the haploid pustules of each physiologic race produced aecia when pycnial nectar of unisexual pustules of the other race was applied to them

suggests complete interfertility, *i.e.*, that the (+) and (—) haploid elements of the two races are capable of combining as readily as those within each race. It should, nevertheless, be pointed out that these results alone are not sufficient proof of interfertility unless they are supplemented by studies which prove that the aecia formed are actual hybrids between the two races. In only a few instances has the hybrid origin of the aecia been demonstrated; and, in each instance where this was done, the hybrid aecia were formed in *tritici* pustules to which *secalis* nectar had been transferred. Most of the aecia formed in *secalis* pustules to which *tritici* nectar had been applied failed to produce uredinial progeny. In the few instances in which uredinial cultures were secured, the cultures were pathogenically identical with *P. graminis secalis* and, consequently, the aecia may have originated through accidental selfings of the *secalis* race. Therefore nothing can be definitely stated, at present, concerning the formation of hybrid aecia on the *secalis* side of the *tritici-secalis* crosses.

First-Generation Hybrids from tritici-secalis Crosses

The following three crosses[5] were made between the *tritici* and *secalis* races of *Puccinia graminis.*

I. *Puccinia graminis tritici* form 95 × *Puccinia graminis secalis.*
II. *Puccinia graminis tritici* form 30 × *Puccinia graminis secalis.*
III. *Puccinia graminis tritici* form 30 × *Puccinia graminis secalis.*

Cross No. I, between form 95 of *Puccinia graminis tritici* and *Puccinia graminis secalis.*

Cross No. I is summarized in Figure 1 and in Table 2. In this cross there is good evidence that hybridization occurred between the *tritici* and *secalis* races. Five mono-aecial cultures arising from the *tritici* side of the cross were identified as a hitherto undescribed physiologic form, which is designated as form 111 of the *tritici* race of *P. graminis.* The reactions of the differential wheat varieties to this form are so radically at variance with reactions to any known form of wheat stem rust that it is doubtful whether it is justifiable to consider the hybrid form a strain of *Puccinia graminis tritici.* On the basis of its pathogenic characters, it would be more correct to relegate the hybrid to a position intermediate between the

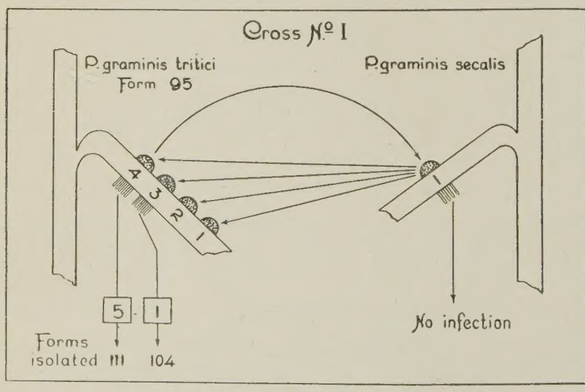

Figure 1. Diagram illustrating cross No. I. The arrows connecting the two barberry leaves indicate the direction of transfer of pycnial nectar. The figures enclosed in the squares represent the mono-aecial rust cultures derived from each aecial pustule. The figures below the squares represent the two physiologic forms identified.

[5] The term "cross" is here used to designate the transfer of pycnial nectar from haploid pustules of *Puccinia graminis tritici* to haploid pustules of *Puccinia graminis secalis* or *vice versa.*

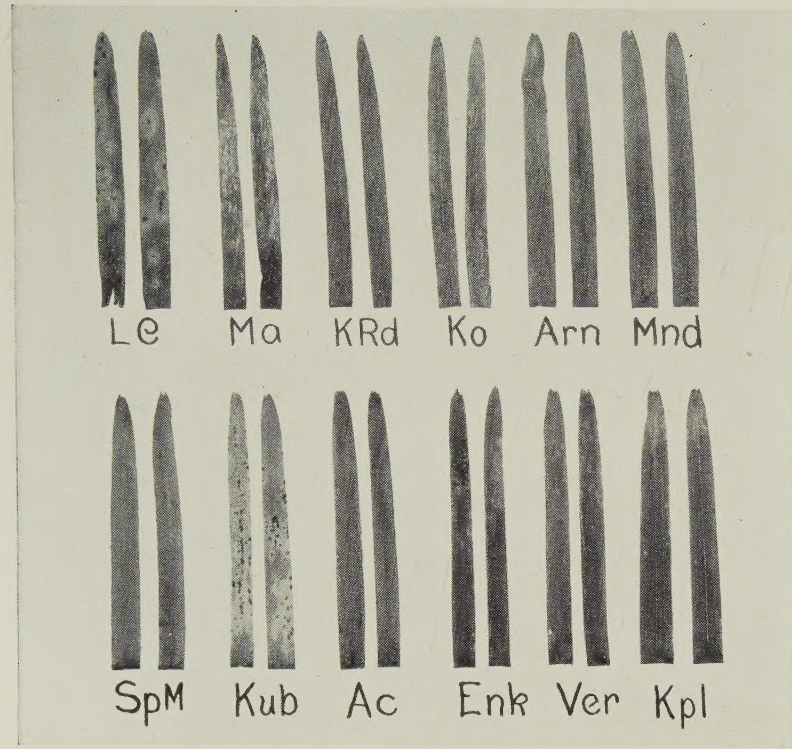

Figure 2. Reactions of differential wheat varieties to physiologic form 111, obtained from Cross I between *P. graminis tritici* form 95 and *P. graminis secalis*.

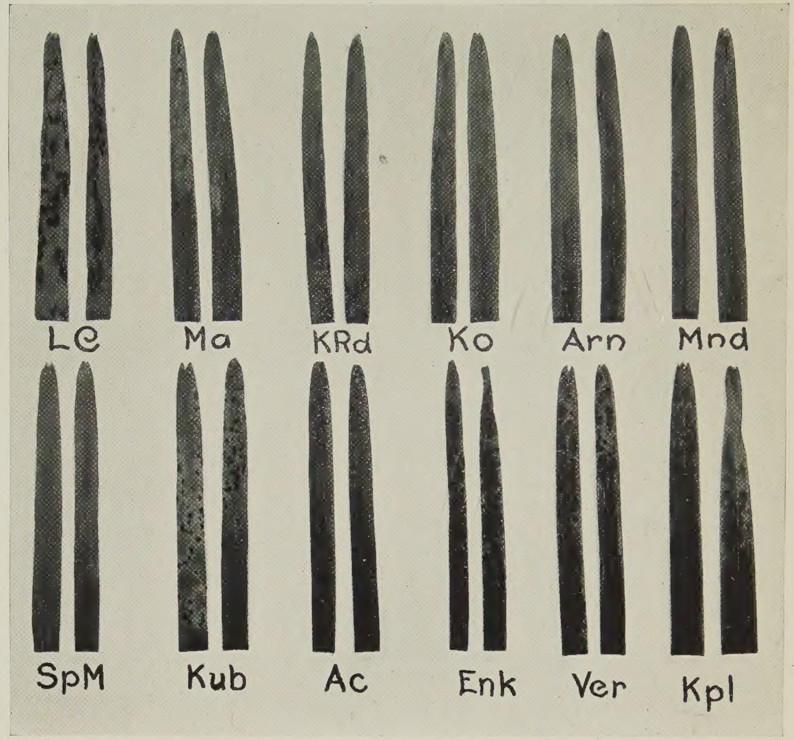

Figure 3. Reactions of differential wheat varieties to physiologic form 104, obtained from Cross I between *P. graminis tritici* form 95 and *P. graminis secalis*.

two parental rust races. The most striking characteristic of this hybrid is its extremely low virulence on wheat varieties. Eleven of the twelve wheat differential varieties are immune to it. The remaining differential variety, Little Club, is semi-resistant (Figure 2). Two varieties of rye, which were inoculated, proved resistant, but several varieties of barley were found moderately susceptible. *Agropyron tenerum, Dactylis glomerata, Bromus inermis, Phleum pratense* were immune, and *Elymus macounii* showed a rather high degree of resistance.

This cross produced, in addition to form 111, another form which is probably the result of hybridization between the *tritici* and *secalis* races. This form, namely, form 104, originated from the transference of pycnial nectar from pustule 1, of *P. graminis secalis,* to pustule 3 of form 95. Form 104 resembles form 111 to a certain extent, differing, however, in its types of infection on the varieties Marquis, Einkorn, and Vernal (Table 2 and Figure 3). The two varieties of rye which were tested proved resistant. The low virulence of these two forms and the similarity of their host reactions suggest that they are hybrids between the *tritici* and the *secalis* races of *Puccinia graminis.*

Cross No. II, between form 30 of *Puccinia graminis tritici* and *Puccinia graminis secalis.*

In this cross, physiologic form 30 of the *tritici* race was crossed with the *secalis* race (Figure 4). Pycnial nectar was transferred from pustule 1 of the *secalis* race to pustules 1 and 2 of form 30. Aecia were formed in pustule 1 of form 30 but not in pustule 2. A reciprocal transfer was made from pustule 2 of form 30 to pustule 1 of the *secalis* race, and aecia were formed in the latter pustule. The development of aecia in *secalis* pustule 1 but not in *tritici* pustule 2 may probably be explained by transmission of extraneous nectar to the former through some unknown agency.

The aeciospores from pustule 1 of the *secalis* race failed to produce infection on wheat or rye seedlings. Consequently investigations were limited to the rust arising on the *tritici* side of the cross. One culture only was established. The infections of this rust culture on the differential wheat varieties proved it to be identical with physiologic form 70 which was originally obtained by Stakman, Levine, and Cotter (*8*) as a hybrid

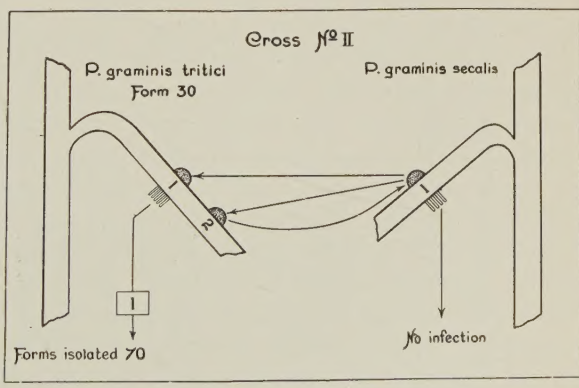

Figure 4. Diagram illustrating cross No. II. The arrows connecting the two barberry leaves indicate the direction of transfer of pycnial nectar. The figure enclosed in the square shows that one mono-aecial rust culture was studied, and the figure below the square shows that physiologic form 70 was identified.

TABLE 2.—*Mean reactions produced by the parent forms used in the tritici-secalis crosses and by the hybrid forms on stem rust differential wheat varieties and on rye and barley.**

		L.C.	Ma.	Krd.	Ko.	Arn.	Mnd.	SpM.	Kub.	Ac.	Enk.	Ver.	Kpl.	Rye	Barley
Cross I.	*Tritici* parent form 95	4	2	3±	1	4	4	4	4	3+	1	1	1	0;	3
Tritici f. 95 x *Secalis*	Hybrid form 111	3±c	1–	0	0;	0;	0;	0;	1	0;	1–	0;	1–	1–	3
	Hybrid form 104	4	X–	0	0;	0;	0;	0;	1	0;	3	X	0;	1–	3
	Secalis parent	0;	0	0	0	0	0	0	0	0	0	0	0	4	3
Cross II.	*Tritici* parent form 30	4	4	0	3++	X	X	X	X	X	3+	4=	1	0;	3
Tritici f. 30 x *Secalis*	Hybrid form 70	3	X+	0	0;	0;	0;	0;	0;	0;	1=	X	1=	1	3
	Secalis parent	0;	0	0	0	0	0	0	0	0	0	0	0	4	3
Cross III.	*Tritici parent form 30*	4	4	0	3++	X	X	X	X	X	3+	4=	1	0;	3
Tritici f. 30 x *Secalis*	*Hybrid form 112*	4	X	0	0;	0;	0;	0;	X–	0;	3	0;	1=	1–	3
	Secalis parent	0;	0	0	0	0	0	0	0	0	0	0	0	4	3

Explanation of symbols:
0 – absolute immunity,
1 – high resistance,
2 – moderate resistance,
3 – moderate susceptibility,
4 – complete susceptibility,
X – indeterminate reaction,
(;) – hypersensitive flecks,
(++) (+) (-) and (=) indicate quantitative variations in the above-mentioned types.

* The authors are indebted to Dr. E. C. Stakman and Dr. M. N. Levine for assigning numbers to the *tritici-secalis* hybrid forms 104, 111, and 112.

between the *tritici* and the *secalis* races of *Puccinia graminis*. The general resemblance of this form to forms 111, 104, and 112 (Table 2), together with the fact that it has previously been described as a *tritici-secalis* hybrid, leaves little doubt as to its hybrid origin.

Cross No. III between form 30 of *Puccinia graminis tritici* and *Puccinia graminis secalis*.

In addition to crosses I and II, a third cross was made, which, however, has not yet been fully investigated. One culture arising from the *tritici* side of the cross has been studied and identified as physiologic form 112 (*vide* Table 2), a form which had not hitherto been described. Infections produced by this form on *Triticum* differential varieties and on barley and rye varieties, indicate a rather striking similarity to the above-mentioned hybrid forms 70, 104, and 111. The reasons already given for considering these forms hybrids apply equally to form 112. The hybrid nature of this form is also supported by the fact that a selfing of the *tritici* parent form did not yield any forms resembling it.

A Cross Between Puccinia graminis tritici and Puccinia graminis agrostidis

Crosses between these two physiologic races might be expected, on theoretical grounds, to yield some interesting information. The *agrostidis* race is physiologically farther removed from *P. graminis tritici* than is the *secalis* race. The *secalis* and *tritici* races possess in common the power of attacking barley and a number of species of wild grasses. The *agrostidis* and *tritici* races have each a well-defined host range: neither race attacks the uredinial hosts of the other. It would consequently be of interest to compare the parasitic properties of *tritici-secalis* hybrids with those of *tritici-agrostidis* hybrids.

Crosses between *P. graminis tritici* and *P. graminis agrostidis* have been reported by Stakman, Levine and Cotter (*8*). The parents used in their crosses were *P. graminis tritici* form 36, and a collection of *P. graminis agrostidis* gathered out-of-doors. They transferred nectar from haploid *tritici* pustules to haploid *agrostidis* pustules, and *vice versa.* Progeny was obtained only from the *tritici* side of the cross, since no aecia were formed as a result of the transfer of *tritici* nectar to *agrostidis* pustules. The uredinial progeny was resolved into many different strains, some of which are well-known *tritici* forms. Some, however, are decidedly unusual in the reactions produced on the differential wheat varieties. One form in particular, form 72, is characterized by low virulence both on common and durum wheat varieties and by high virulence on Einkorn and the emmer wheats, including Khapli which is resistant to practically all known *tritici* forms. None of the forms isolated are capable of infecting species of *Agrostis.*

Further evidence is available on hybridization between *P. graminis tritici* and *P. graminis agrostidis* through crossing experiments carried out

by the present authors. In most of the crosses which were attempted, physiologic form 9 was used as the *tritici* parent. This form has been selfed on several occasions, and in every instance its progeny has been identified as form 9. The fact that this form is homozygous for pathogenicity makes it valuable for crossing purposes and permits the assumption that any form other than form 9 which might originate from the form-9 side of an inter-racial cross would be of hybrid origin. In one of the crosses, form 11 was utilized as the *tritici* parent. The *agrostidis* parent was a field collection of teliospores on *Agrostis alba* gathered in New Brunswick, Canada.

Considerable difficulties were experienced in obtaining aecial formation as a result of transfer of pycnial nectar from haploid pustules of one parent to haploid pustules of the other parent. In fact, the writers were for some time of the opinion that the two races were inter-sterile. In the seven crosses attempted, pycnial nectar was transferred from *agrostidis* pustules to 14 haploid *tritici* pustules (Table 3). Aecia were formed in only three pustules, and, in two of these, it was evident that the aecia arose through a fortuitous selfing of form 9, as was indicated by the fact that the uredinial progeny of the aecia was in all cases identified as form 9. The aecia of the third pustule were evidently of hybrid origin as will be shown later.

TABLE 3.—*Results of transferring pycnial nectar from haploid pustules of the tritici race to haploid pustules of the agrostidis race and vice versa.**

	P. graminis tritici		*P. graminis agrostidis*	
	No. of pustules to which nectar was transferred	No. of pustules in which aecia were formed	No. of pustules to which nectar was transferred	No. of pustules in which aecia were formed
Cross I	3	0	1	0
Cross II	3	0	Mass transfer of nectar of many haploid pustules	–
Cross III	1	0	6	0
Cross IV	4	2†	1	0
Cross V	1	1	10	0
Cross VI	1	0	12	3†
Cross VII	1	0	6	0
Total	14	3	36	3

*The procedure followed in each cross was to transfer nectar from one pustule of one parent race to several pustules of the other race. A reciprocal transfer was then made from one of these pustules to the pustule from which the nectar was originally taken. For example, in Cross I nectar was transferred from one pustule of the *agrostidis* race to three pustules of the *tritici* race, and a reciprocal transfer was then made from one of the *tritici* pustules to the *agrostidis* pustule.

†The aecia formed in these pustules evidently arose as a result of selfing.

Pycnial nectar was also transferred from *tritici* pustules to 36 haploid *agrostidis* pustules. Three, only, of these pustules gave rise to aecia. The infections of the uredinial progeny from these aecia were identical with those of *P. graminis agrostidis,* and thus indicate a complete *agrostidis* inheritance. In two of these pustules, the presence of aecia may be explained by the coalescence of these two pustules, as aecia formed rather belatedly at the point of contact. Selfing by an unknown agency must have occurred in the third pustule. It is apparent, then, that there is at least a partial inter-sterility between the *tritici* and *agrostidis* races. These results agree with the experience of Stakman, Levine, and Cotter, who were unable to bring about the formation of aecia in haploid *agrostidis* pustules by applying to them the nectar from *tritici* pustules.

Figure 5. Reactions of Little Club wheat and *Agrostis alba* to the *tritici-agrostidis* hybrid form.

As stated above, aecia of hybrid origin were formed in one pustule on the *tritici* side of one of the crosses. Four uredinial cultures of mono-aecial origin were established from this pustule. These cultures proved identical in their infections on the wheat differential hosts. Eleven of the twelve hosts were immune or highly resistant (*vide* Table 4); the remaining variety, Little Club, was moderately resistant, the reactions varying from "1 + " to "X = ". Although a number of other varieties of common wheat have been tested, none have proved more susceptible than Little Club. *Agrostis alba* appears to possess about the same degree of resistance to the hybrid form as does Little Club, while certain barley varieties which were tested showed reactions varying from high resistance to moderate susceptibility. Figure 5 shows the reactions of Little Club and *Agrostis alba.*

Discussion

In undertaking the inter-racial crosses discussed in this paper, the authors had two main objects in view: first, to determine the capability of *P. graminis tritici* to hybridize with other physiologic races of *Puccinia graminis* and, second, to determine the pathogenicity towards *Triticum* species of any hybrid forms which might be obtained. It was originally intended to cross the *tritici* race with the *secalis, agrostidis,* and *avenae* races. As has already been stated, only the first two of these races were crossed with the *tritici* race. Two other races of *P. graminis* occur in North America, *P. graminis poae* and *P. graminis phlei-pratensis,* but the former occurs rarely in Canada and no teliospores of this race were available when the above-mentioned crosses were made. *P. graminis phlei-pratensis* does not infect *Berberis* species, as far as is known, and for this reason was left out of consideration.

TABLE 4.—*Reactions produced by parent rust strains used in the tritici-agrostidis cross and by the hybrid form on cereal and grass hosts.*

	Reactions to		
	P. graminis tritici form 9	*P. graminis agrostidis*	*Tritici-agrostidis* hybrid
Differential Hosts			
Little Club	4	0	1 to X–
Marquis	4–	0	0; to 1
Kanred	0	0	0
Kota	3++	0	0; to 1=
Arnautka	4–	0	0;
Mindum	4–	0	0;
Speltz Marz	4=	0	0;
Kubanka	4=	0	0;
Acme	3++	0	0;
Einkorn	3+	0	0; to 2
Vernal	4=	0	0;
Khapli	1–	0	1=
Other Wheat Varieties Differential Hosts			
Garnet	4–	0	0; to 1=
Prelude	4	0	0;
Hard Federation	4	0	0; to 1=
Renfrew	4	0	1
Power	4–	0	0; to 1
Ruby	4–	0	0;
Barley Varieties			
O.A.C. 21	3–	0	1 to 3
Canadian Thorpe	1+	0	0; to 3
Peatland	1–	0	0; to 1=
Odessa	2	0	0; to 2
Agrostis alba	0	2 to 3	1+ to 2

For explanation of symbols see table 2.

Stakman, Levine, and Cotter (*8*) have reported a number of crosses between *P. graminis tritici* form 36 and *P. graminis secalis* form 11. The F_1 progeny of these crosses was resolved into eight physiologic forms of *P. graminis tritici,* namely, forms 15, 21, 32, 36, 57, 67, 70, and 71, and two physiologic forms of *P. graminis secalis,* forms 9 and 11. As far as can be judged from the pathogenicity of these forms, only two of them, forms 70 and 71, show reactions that might be considered intermediate between those of the *tritici* and *secalis* races. Both of these forms are low in virulence on all the wheat differential hosts except Little Club; even the variety Acme, which is susceptible to almost all *tritici* forms, is immune to forms 70 and 71. The remainder of the forms are either typical *tritici* or typical *secalis* forms. These forms may be hybrids in which *tritici* or *secalis* characters respectively predominate or, possibly, they may have resulted from accidental selfing of one or the other of the parental forms.

In the F_1 progeny of the three *tritici-secalis* crosses described in this paper, there appear four distinct physiologic forms, namely, forms 70, 104, 111, and 112. These forms are remarkably weak in their pathogenicity on wheat varieties (*vide* Table 2) and even weaker in pathogenicity on rye

varieties. They lack the ability to infect the variety Acme which, as mentioned above, is susceptible to almost all physiologic forms of the *tritici* race. The four forms, although distinguishable, are strikingly similar in their differential host reactions and form, together with form 71 (previously described by Stakman, Levine, and Cotter as a *tritici-secalis* hybrid) a well-defined group possessing pathogenic characters which may be considered more or less intermediate between those of the *tritici* and the *secalis* races of stem rust.

The presence in the F_1 generation of *tritici-secalis* crosses of widely varying types of rust strains raises the question as to whether all these forms are to be considered as hybrids between these two physiologic races. This question is rendered yet more complicated by the fact that Levine and Cotter (*4*) have described a *tritici-secalis* hybrid which differs pathogenically from all of the above-mentioned rust strains. This hybrid differs from both parental forms in possessing the ability to attack both wheat and rye varieties rather severely. Hence this hybrid possesses to a large degree the combined parasitic properties of the two parental rusts.

One of the objects of making crosses between the *tritici* and other races is to discover the characteristic pathogenic properties of the hybrids. An analysis of the available data shows to what extent this objective has been attained. If it is assumed that all the forms reported in the F_1 progeny of the various crosses are hybrids, it becomes apparent that there are at least four distinct types of *tritici-secalis* hybrids: (1) typical *tritici* forms, such as forms 15, 21, 32, 36, 57, and 67 reported by Stakman, Levine, and Cotter; (2) typical *secalis* forms such as forms 9 and 11, also reported by Stakman *et al;* (3) forms with pathogenic properties more or less intermediate between those of the *tritici* and *secalis* races, comprising forms 70 and 71 reported by Stakman *et al* and forms 70, 104, 111, 112 reported by the present authors; and (4) forms with the combined parasitic characters of the two parental races, such as the one reported by Levine and Cotter. If all these forms are considered authentic hybrids, it is manifestly impossible to ascribe any definite pathogenic characteristics to *tritici-secalis* hybrids in general. There is no conformity to any one type. It is, however, quite possible that the forms in groups 1 and 2 are not hybrids at all, but that they were produced through fortuitous selfings of the parents. The forms in groups 3 and 4 are in all probability hybrids. It is true that all the evidence for the hybrid nature of these forms is as yet circumstantial. It should, however, be possible to demonstrate the hybrid or non-hybrid origin of these forms through a study of their breeding behaviour when selfed. Forms which resulted from accidental selfing of the *tritici* or *secalis* races should produce *tritici* or *secalis forms* respectively; but forms which originated as inter-racial hybrids should, on selfing, produce some *tritici* forms and some *secalis* forms in addition to forms which are distinctly different from either parent in respect to pathogenicity. The present authors have already attempted progeny studies on forms 70, 104, 111, and 112 without any success, owing to their failure to induce the teliospores to germinate. The fact that these teliospores did not germinate is perhaps another evidence for their hybrid origin, for

they have resisted methods which have been uniformly successful in inducing the teliospores of numerous *tritici* forms to germinate.

An interpretation of the results of the *tritici-agrostidis* crosses which have been made thus far is confronted by much the same difficulties as those already outlined in the discussion of the *tritici-secalis* crosses. In the *tritici-agrostidis* crosses reported by Stakman, Levine, and Cotter, all the aecial progeny originated on the *tritici* side of the crosses, and the rust strains identified were definitely of the *tritici* type. The *tritici* characteristics of these strains must be explained in one of two ways. Either these strains are hybrid forms in which *tritici* characters predominate, or they are not of hybrid origin but have resulted from accidental selfing of the *tritici* race. The latter alternative is perhaps the more probable in view of the results which the present authors have obtained in their *tritici-agrostidis* cross.

The *tritici-agrostidis* hybrid discussed in this paper bears a marked resemblance to the *tritici-secalis* hybrid form 111. Its pathogenicity towards wheat is even weaker than that of form 111, for all wheat varieties so far tested have been highly resistant. There are three reasons for considering this form a hybrid. In the first place, no physiologic form of equally low virulence has yet been discovered, either in nature or through experimental hybridization among physiologic forms of the *tritici* race. It is indeed doubtful if the rust should be considered a *tritici* form, for it is unlikely that a strain of such exceptionally low virulence could be perpetuated on wheat varieties growing in nature. In the second place, the rust has the ability to attack *Agrostis alba,* which is immune to wheat stem rust. And in the third place, it seems highly improbable that the rust could have originated in a selfing of the *tritici* parent form 9 for the reason that form 9 has proven homozygous for pathogenicity in all selfing experiments, including those carried out simultaneously with the crossing.

The parasitic properties of this hybrid are to some extent intermediate between those of the two parent races, but its ability to attack barley varieties indicates a greater resemblance to the *tritici* than to the *agrostidis* race. The resemblance of its host reactions to those of the weakly pathogenic *tritici-secalis* hybrids suggests that strains of weak parasitism may be expected to occur frequently in crosses of the *tritici* race with other races of stem rust.

Summary

1. Crosses have been made between *Puccinia graminis tritici* and *Puccinia graminis secalis.* Four physiologic forms have been isolated from the first-generation progeny of these crosses. The pathogenic properties of these forms indicate that they are actual hybrids between the two physiologic races. These four forms, 70, 104, 111, and 112, are low in virulence on the majority of wheat varieties and on rye, but attack barley varieties to about the same degree as the parent forms.
2. A number of crosses between *P. graminis tritici* and *P. graminis agrostidis* were attempted. No hybrid aecia were formed in any of the haploid *agrostidis* pustules to which *tritici* nectar was applied; but

aecia of hybrid origin were formed in one of the haploid *tritici* pustules to which *agrostidis* nectar was applied. The difficulty of securing hybrid aecia suggests a partial inter-sterility between these two physiologic races.

3. The *tritici-agrostidis* hybrid aecia produced a strain of rust very similar in pathogenic properties to the *tritici-secalis* hybrid form 111, but even less virulent than it on wheat, for all the varieties which have been tested have proved either immune or resistant. *Agrostis alba,* which is susceptible to the *agrostidis* race, is moderately resistant to the hybrid rust, while barley varieties are either resistant or moderately susceptible.
4. The similarity of the pathogenic characters of the *tritici-secalis* hybrids and the *tritici-agrostidis* hybrid suggests that hybrid forms of this type may be expected to occur frequently in crosses of the *tritici* race with other races of *P. graminis.*

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THE EFFECT OF SMUT ON RUST DEVELOPMENT AND PLANT VIGOUR IN OATS[1]

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Introduction

In plant pathological investigations the effect of one disease upon another is of considerable importance in estimating the degree of resistance of strains or varieties to any one disease-producing organism. In the present study results are obtained for four varieties of oats on the effect of smut infection on the development of stem and crown rust. In addition, a comparative study is made of the vigour of groups of plants with different degrees of smut infection.

Previous Investigations

Certain observations and studies have been made with wheat on the effect of smut on rust development. Lang (*5*) and Armstrong (*1*) observed that bunted plants were more susceptible to yellow rust than those non-bunted. Dillon Weston (*2*) made a more detailed study and found that there was an increase in susceptibility of varieties to yellow rust when infected with bunt *Tilletia tritici* (Bjerk) Winter. Vilkaitis (*8*) made a similar study and stated that leaves on stalks infected with *Tilletia caries* (D.C.) Tul., bearing bunted ears were the most susceptible to yellow rust and those free from bunt the least susceptible while leaves on stalks free from bunt but belonging to bunted stools were intermediate. Hart (*4*) noted that smutted wheat plants are likely to become more heavily rusted than healthy plants. With oats, previous studies by the writer (*9*) lead to the conclusion that smutted plants were more heavily rusted than those non-smutted.

With regard to the question of the effect of smut on plant vigour it is well known that infection by *Tilletia tritici* (Bjerk.) Winter, causes a reduction in plant height. Vilkaitis (*7*) showed that bunt reduced the height of plants by 25% and increased tillering by 49%. Smith and Bressman (*6*) point out that there is a possibility of a reduction in yield in smut infected plants in which there are no outward indications of the disease.

Materials and Methods

In the present study four oat varieties, Heigira Strain[3], Iogold, Monarch Strain, and Richland were used. These varieties are resistant to stem rust, *Puccinia graminis avenae* (Pers.) Erikss. and Henn., but susceptible to crown rust, *Puccinia coronata avenae* (Corda) Erikss. and Henn. and to both loose and covered smuts, *Ustilago avenae* (Pers.) Erikss. and Henn. and *Ustilago levis* (K. and S.) Magn., respectively.

[1]Contribution from the Cereal Division, Experimental Farms Branch, Department of Agriculture, Ottawa, Canada.
[2]Cerealist.
[3]According to the U.S.D.A. Bulletin 143, the correct spelling is Hajira.

The experiment was conducted under both field and greenhouse conditions. For the field studies the varieties were inoculated with both loose and covered smuts. One thousand seeds of each variety were dehulled and divided into four 250 seed lots. One lot was inoculated with loose smut and another with covered, the two remaining ones serving as checks. All were sown the latter part of April, 1931. Later, about the last week in June, an artificial rust epidemic was induced by transplanting plants inoculated with all the common forms of stem rust at intervals around the plots. At maturity all plants in the smut inoculated lots, showing smutted panicles, were pulled. From the remaining plants as well as from the checks, a similar number were taken at random. Each variety, therefore, in the loose and in the covered smut inoculated lots consisted of three groups of plants, viz. (1) inoculated, with smutted panicles, (2) inoculated, with non-smutted panicles and (3) the uninoculated plants. Each group was studied separately as to rust infection, height, and stage of maturity, these notes being taken separately on the tillers of each plant. The tillers were classified, in addition, as mature or immature, the latter class comprising all tillers with green coloration. Rust infection was read on a scale of one to ten points, no attempt being made to differentiate between stem and crown rust. Height measurements were taken to the base of the panicles only, as the upper portion of a great number of the panicles was missing.

A somewhat similar experiment was conducted under greenhouse conditions in which seedling reaction was studied. Two varieties, Heigira Strain and Monarch Strain were used. Six hundred seeds of each variety were dehulled and of this number one hundred and fifty were inoculated with loose smut, and later the seedlings were inoculated with rust forms to which the varieties were known to be resistant. The same number of seeds were inoculated with covered smut and the seedlings also inoculated with rust. The remaining three hundred seeds were used as checks and consquently were not inoculated with smut. The seedlings, however, were inoculated with rust.

Experimental Results

The effect of smut infection on the development of rust in the seedling and mature plant stages and a study of the comparative vigour of plants with different degrees of smut infection will be treated separately in the following discussion. In referring to the three groups of plants previously described it will be convenient to refer to the inoculated smutted plants as "smutted", the inoculated non-smutted plants as "smut-free", and the uninoculated plants as "checks".

In the data on the effect of smut on rust development the variety, Richland, had to be omitted as the plants in the smutted group became mouldy, thus making the rust readings very inaccurate.

Effect of Smut on the Development of Rust

The results of the investigation demonstrated that, under greenhouse conditions, no difference in the amount of rust infection could be discerned

TABLE 1.—*Average rust infection and number of mature and immature tillers for groups of plants classified according to inoculation and uninoculation and presence or absence of smutted panicles.*

Varieties	Smut Type	Inoculated												Uninoculated			
		Smutted Plants								Smut-Free Plants				Check			
		Tillers with Smutted Panicles				Tillers with Non-Smutted Panicles											
		Number of Tillers		Average Rust Infection		Number of Tillers		Average Rust Infection		Number of Tillers		Average Rust Infection		Number of Tillers		Average Rust Infection	
		Mat.	Immat.	Mat.	Immat.	Mat.	Immat.	Mat.	Immat.	Mat.	Immat.	Mat.	Immat.	Mat.	Immat.	Mat	Immat.
Heigira Strain	Loose	206	253	.74	6.0	85	47	.70	4.0	308	209	.20	1.9	414	141	.10	1.1
	Covered	143	135	.42	3.6	45	36	.49	2.7	274	185	.11	1.9	298	104	.11	1.7
Iogold	Loose	176	100	.12	3.2	116	37	.06	1.7	287	158	.10	1.8	336	73	.14	1.7
	Covered	69	41	.62	4.0	71	34	.27	2.6	156	83	.19	2.0	200	37	.09	1.4
Monarch Strain	Loose	114	239	1.10	4.1	38	55	1.10	4.3	163	185	.36	3.5	195	45	.50	2.8
	Covered	27	60	.33	2.1	30	53	.03	1.2	87	81	.07	1.4	79	94	.14	1.2
All Varieties	Loose and Covered	735	828	0.56	4.34	385	262	0.39	2.81	1275	901	0.17	2.18	1522	494	0.16	1.51
Ratio of Immature to Mature Tillers		1.13				0.68				0.71				0.32			

TABLE 2.—*Average height in inches of plant tillers, classified according to smut infection and maturity.*

Varieties	Smut Type	Inoculated								Uninoculated		
		Smutted Plants					Smut-Free Plants			Check		
		Average Height of Tillers				Average Height of All Tillers	Average Height of Tillers		Average Height of All Tillers	Average Height of Tillers		Average Height of All Tillers
		With Smutted Panicles		With Non-Smutted Panicles								
		Mat.	Immat.	Mat.	Immat.		Mat.	Immat.		Mat.	Immat.	
Heigira Strain	Loose	19.6	18.4	22.3	19.4	19.4	23.5	19.7	22.0	23.6	21.4	23.0
	Covered	16.2	14.5	21.5	17.1	16.3	21.5	18.3	20.2	22.8	19.0	21.8
Iogold	Loose	18.7	15.7	22.0	18.0	18.8	21.8	18.3	20.6	21.8	19.0	21.3
	Covered	15.7	14.0	18.3	15.3	16.2	19.1	15.6	17.9	21.4	17.0	20.7
Monarch Strain	Loose	21.9	17.8	25.3	20.2	19.8	25.1	19.5	22.1	27.2	20.6	24.7
	Covered	20.8	20.2	26.8	21.3	21.8	27.3	23.4	25.4	28.8	23.5	25.9
Richland	Loose	17.1	15.0	19.8	16.4	16.8	19.0	16.6	17.8	20.0	17.4	18.7
	Covered	16.4	14.8	19.6	17.6	16.8	20.8	17.8	18.9	21.1	18.8	19.7
All Varieties	Loose and Covered	18.3	16.3	22.0	18.2	18.2	22.3	18.6	20.6	23.3	19.6	22.0

between smut inoculated and uninoculated seedlings, while under field conditions, differences between smutted and non-smutted mature plants did occur. The data on mature plants are given in Table 1.

The salient points demonstrated in the table may be enumerated as follows: (1) Plants with smutted panicles are more heavily rusted than plants free from smut; this is also true for mature and immature tillers. (2) In plants of the smutted group, tillers with smutted panicles are more heavily rusted than those with non-smutted panicles but the latter are more heavily rusted than tillers of smut-free plants. (3) Immature tillers are more heavily rusted than the mature and this difference is accentuated for tillers with smutted panicles. (4) Plants inoculated but free from smut are rusted more heavily than uninoculated plants.

Since immature tillers are rusted more than the mature the conclusion might at first seem obvious that if in smutted plants there is a higher ratio of immature to mature tillers, this would account for the difference in rust infection. The data show, however, that for both classes of tillers smut infection results in a greater susceptibility to rust even when the smut infection is not severe enough to cause smutting of the panicles. This effect is not as evident in the mature tillers as in the immature but seems sufficiently pronounced to indicate that smut infection predisposes plants to rust.

Effect of Smut on Plant Vigour

In this study differences in height, number of tillers and yields were determined for smutted, smut free, and check plants. Figure 1 shows for Heigira Strain the differences, which are typical of all four varieties, between the three groups of plants in height and size of sheaf of an equal number of plants.

Height Although it is a generally accepted fact that smut infection causes a reduction in plant height, data on the height of plants was recorded to determine, firstly, the difference in height, on the same plant, between tillers with smutted and non-smutted panicles; secondly, to compare the height of tillers of inoculated smut-free plants with the uninoculated; thirdly to compare the average height of all three groups, and finally to compare the relative effect of loose and covered smut infection on plant height. The results are presented in Tables 2, 3 and 4.

As is shown in Table 2 both the mature and immature tillers in the smutted plants are much shorter than the uninoculated and those of the smut-free plants are intermediate. This fact is also evident from the averages calculated for each variety and for all four varieties taken as a group. Further, within the group of smutted plants both the mature and immature tillers with non-smutted panicles are taller than the smutted.

From the data in Table 2 it would appear that for the varieties Heigira Strain and Iogold, covered smut causes the greatest reduction in plant height, and for the varieties Monarch Strain and Richland, loose smut apparently causes the greatest reduction. However, as the same differences are characteristic of the check plants it is possible that these differences may be due to soil variation. On the other hand, it is possible

that the differences in reduction in height caused by the two smuts may be the result of specialization in some degree. The relationship between height and the percentage of tillers smutted for each variety is given in Table 3.

TABLE 3.—*Correlation Coefficients for loose and covered smut infection with plant height and number of tillers.*

Variety	Smut Infection with Height		Smut Infection with Number of Tillers	
	Loose Smut	Covered Smut	Loose Smut	Covered Smut
Heigira Strain	−.50	−.53	−.26	−.52
Iogold	−.74	−.42	−.30	−.72
Monarch Strain	−.37	−.49	−.29	−.76
Richland	−.57	−.64	−.30	−.76
All Varieties	−.56	−.55	−.28	−.56

These correlations all show that smut infection causes a significant reduction in height. The average correlations at the foot of the table were obtained from the other coefficients by the z transformation, Fisher (*3*). There are no very pronounced differences, for any of the varieties, between the reductions in height due to loose and covered smut, while the averages for all of the varieties are practically identical.

In order to further determine differences, if any, between the effects of loose and covered smut infection in plant height the data in Table 2 were summarized by treating all varieties as a single entity and averaging the height of plant tillers in the loose and in the covered smut groups. The results are given in Table 4.

TABLE 4.—*Average height of tillers, of the four varieties, in the loose and in the covered smut groups.*

Smut Type	Inoculated						Uninoculated	
	Smutted Plants				Smut Free Plants		Check Plants	
	Tillers with Smutted Panicles		Tillers with non-Smutted Panicles					
	Mat.	Immat.	Mat.	Immat.	Mat.	Immat.	Mat.	Immat.
Loose	19.3	16.7	22.4	18.5	22.4	18.5	23.2	19.6
Average	18.0		20.5		20.5		21.4	
Covered	17.3	15.9	21.6	17.8	22.2	18.5	23.5	19.5
Average	16.6		19.7		20.4		21.5	

From the data in Table 4 it is evident that in tillers with smutted panicles, covered smut infection reduces height to a greater extent than does loose smut infection. On the other hand, no such differences are apparent in tillers of smutted plants not bearing smutted panicles or in the smut free and check plants. Such a result would indicate that covered smut infection does reduce plant height to a greater extent than loose smut.

Tillering As indicated in Table 1, one of the most obvious effects of smut infection is to increase the ratio of immature to mature tillers. As calculated from the data in Table 1 this ratio for the different groups is as follows:—

Inoculated, smutted plants—0.97.
Inoculated, smut-free plants—0.71.
Uninoculated, check plants—0.32 .

The average number of tillers per plant is also affected by smut infection. The data in table 5 give the average number of tillers per plant for the four varieties classified according to smut treatment and degree of infection. The smutted group is divided into "totally smutted" and "partially smutted" plants.

Figure 1. Sheaves of an equal number of plants of Heigira Strain showing the effect of smut infection on height and size.
Left:— Inoculated plants with smutted panicles.
Centre:— Uninoculated plants.
Right:— Inoculated plants with non-smutted panicles.

TABLE 5.—*Average number of tillers per plant for four varieties, according to smut treatment and degree of infection.*

Treatment	Smut Infection	Heigira Strain		Iogold		Monarch Strain		Richland		Average No. of Tillers all Varieties
		No. of Plants	Average No. of Tillers	No. of Plants	Average No. of Tillers	No. of Plants	Average No. of Tillers	No. of Plants	Average No. of Tillers	
LOOSE SMUT	Totally Smutted	46	9.3	43	9.0	66	9.4	14	7.5	8.80
	Partially Smutted	36	11.8	64	10.8	23	13.1	20	10.1	11.45
Inoculated	All Smutted Plants	82	11.6	107	10.1	89	10.4	34	9.0	10.28
	Smut Free	54	10.5	64	10.5	92	11.4	34	9.4	10.45
Uninoculated	Checks	55	11.2	61	10.0	44	9.3	33	9.2	9.92
COVERED SMUT	Totally Smutted	49	9.1	14	5.5	8	5.9	10	7.8	7.08
	Partially Smutted	32	16.5	30	10.8	11	9.6	4	11.3	12.05
Inoculated	All Smutted Plants	81	12.0	44	9.1	19	8.0	14	8.8	9.98
	Smut Free	38	12.1	25	10.1	26	8.5	27	15.3	11.50
Uninoculated	Checks	35	12.1	25	10.6	24	9.1	32	11.9	10.92

The data in Table 5 show that in the totally smutted plants there is a decided reduction in the number of tillers per plant especially for covered smut. In the partially smutted plants there is, if anything, an increase in the number of tillers as compared to the checks. The evidence here seems fairly convincing that in partially smutted plants tillering is stimulated, while very heavy infections so affect the general vigour of the plants as to reduce the number of tillers.

Correlation coefficients were also determined for the relation between smut infection and the number of tillers. These are given in Table 3. It is evident that in general, smut infection reduces the number of tillers. Furthermore, the reduction in tillering was much more pronounced for covered smut than for loose smut. The correlation coefficients for all of the varieties are —.28 for loose smut and —.56 for covered smut. The difference between the two coefficients is statistically significant.

Table 6.—*Yield in grams of smutted plants, inoculated smut-free plants, and the check plants.*

Smut Type	Varieties	Inoculated				Uninoculated		Average Yield All Smut Infection Classes
		Smutted		Smut Free		Checks		
		No. of Plants	Average Yield per Plant	No. of Plants	Average Yield per Plant	No. of Plants	Average Yield per Plant	
Loose	Heigira Strain	33	.31	54	4.8	53	6.2	3.77
	Iogold	158	1.50	68	4.1	63	4.8	3.47
	Monarch Strain	37	.41	42	4.6	84	5.9	3.64
	Richland	40	1.30	33	3.3	34	3.4	2.67
	All Varieties	268	.88	197	4.20	234	5.08	3.39
Covered	Heigira Strain	34	.52	38	4.9	63	5.3	3.57
	Iogold	71	1.60	45	3.5	75	5.2	3.43
	Monarch Strain	43	2.10	27	4.0	24	7.0	4.37
	Richland	63	2.20	27	5.8	31	6.5	4.83
	All Varieties	211	1.60	137	4.55	193	6.00	4.05
Loose and Covered	All Varieties	479	1.24	334	4.38	427	5.54	3.72

Yield. The yield figures as given in Table 6 again indicate a reduction in vigour with smut infection. A reduction in yield is of course to be expected when the panicles are smutted but it is not so obvious that smut infection will reduce yields when it is such as not to be evident in the panicles. The data in Table 6 indicate, however, that this is the case and to substantiate this the results were subjected to the variance analysis as shown in Table 7, in which only those plants are dealt with that did not show any smutted panicles.

The difference between the yields of the inoculated smut-free group and the checks is decidedly significant. There is also some evidence for an interaction between varieties and loose and covered smuts. The reason

for this is obvious from the last column of Table 6. The yields for Heigira Strain, Iogold and Monarch Strain are approximately the same for the two kinds of smut but the yield of Richland is reduced to a much greater extent by loose smut than by covered smut.

TABLE 7.—*Yield analysis of variance including smut-free group and check group.*

Variance due to	Sum of Squares	Degrees Freedom	Mean Square	½ Loge of (Mean Sq. x 10)	z	5% Point
Varieties	2.625	3	0.875	1.0845	.3483	.7347
Loose vs. Covered Smut	1.690	1	1.690	1.4137	.6775	.8606
Smut-Free Groups vs. Checks	5.290	1	5.290	1.9843	1.2481	.8606
Interaction, Varieties with Loose vs. Covered Smut	6.665	3	2.222	1.5506	.8144	.7347
Error	3.050	7	0.436	.7362		
Total	19.320	15				

Discussion

The effect of smut infection on the development of rust is of importance to the plant breeder or plant pathologist in estimating disease infections. Obviously oat plants cannot be tested for resistance to smut and rust at the same time and the same may be true with regard to the association of other diseases. In its practical aspect the result is also significant, for in the case of rust resistant varieties it is apparent that a heavy smut infection may cause an additional loss due to rust infection.

Probably the most important result obtained from this study is that smut infection in oat plants, although not evident in the panicles, may bring about a marked reduction in vigour. The losses due to smut are not confined, therefore, to the seeds that are actually destroyed by the fungus.

Summary

1. A study was made of the effect of smut on rust development and plant vigour.
2. Smut infected plants were found to be more heavily rusted than those non-smutted.
3. Smut infection resulted in a higher ratio of immature to mature tillers, caused a reduction in plant height and lowered the yield.
4. Covered smut apparently reduces height to a greater extent than does loose smut.
5. Plants in which all panicles were smutted possessed fewer tillers than normal ones, while those partially smutted exhibited as many and in some cases, more tillers.

6. Plants inoculated with *Ustilago levis* and *Ustilago avenae,* and apparently infected with the mycelium of these organisms although showing no evidence of smutted panicles, were intermediate in stage of maturity, height and yield between obviously smutted and uninoculated plants.
7. In three varieties, covered smut infection reduced tillering to a greater extent than loose smut infection.

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PULLOROM CONTROL IN NEW BRUNSWICK

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The use of the agglutination test to detect fowls infected with pullorum began in Eastern Canada in the flock of the Dominion Experimental Station at Fredericton, New Brunswick, in 1924. For a number of years chick mortality at this station had been abnormally high, reaching the peak in 1923 when only 22.19% of chicks hatched were alive on July 31st (*1*). Most of the mortality was from a disease having as one of its symptoms diarrhoea which developed when the chicks were about a week old. Mortality was high until about the eighteenth day. Surviving chicks were apparently normal as adults but there was some evidence that the years of greatest chick mortality were followed by low average egg production. All known methods of proper flock management were tried in an endeavor to check this mortality but without success. A series of original experiments in which cultures of *Bacillus acidophilus* were fed gave some promise but results were not entirely conclusive.

In February 1924 a number of hens were sent to the Central Experimental farm at Ottawa for examination which revealed the presence of an organism similar to the causal organism of fowl typhoid. In November of the same year blood samples were taken from all birds in the Fredericton flock that were to be retained for breeding purposes and forwarded to Ottawa for testing. Table 1 shows the high percentage of reactors that were detected by this test.

Table 1.—*Results of first test at Dominion Experimental Station, Fredericton, N.B., in 1924.*

	Number of Birds Tested	Number of Reactors	Per Cent Reactors
Females	324	119	36.7
Males	62	14	22.5
Total	386	133	34.4

The reacting birds were slaughtered and the percentage of chicks reared in 1925 showed marked improvment. In the fall of 1925 the entire flock was again tested and the total percentage of reactors was reduced to 3.93%. (*2*). The flock was tested once annually until 1928 with a varying percentage of reactors but with steady improvement in the viability of chicks.

Until the year 1928 the work of testing by the Experimental Farms Branch had been conducted largely as an experiment. Methods of tech-

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nique in applying the test had improved and in that year the Central Experimental Farm advocated the test as a means of increasing the viability of young stock and extended testing work to nearly all flocks in the Experimental Farms System. (*3*).

At the annual meeting of Poultry Producers of New Brunswick (the provincial poultry association of the province) held at Fredericton in August 1925, a resolution was passed urging the Federal Department of Agriculture to establish a laboratory at the Fredericton Experimental Station where the agglutination testing of poultry might be conducted. The request was repeated by the organization at its annual meeting the following year but without result. Poultry breeders felt that pullorum might exist in their flocks but had no laboratory within shipping distance to make tests.

It was well known that diarrhoeal troubles caused some loss each year but this had been attributed more to mismanagement, such as overheating or chilling, than to contagious types of diarrhoea. No noticeable increase or dangerous mortality was evident generally throughout the province until the spring of 1928. Very heavy losses occurred that year (*4*) among chicks sent out by a commercial hatchery using cabinet type forced draft incubators.

Late in 1927 a commercial laboratory equipped to apply the agglutination test to poultry blood samples started business in Ottawa and was thus within shipping distance of New Brunswick. Following the heavy mortality in the spring of 1928 the Department of Agriculture of New Brunswick undertook to supervise a province-wide campaign of poultry blood testing, designed to include flocks owend by hatchery men and others supplying commercial hatcheries with eggs. Blood samples were taken by officials of the Department of Agriculture and testing done at the Ottawa laboratory.

Table 2 gives a summary of the testing done in 1928 showing the percentage of reactors in males and females separately and totals for both together in the different breeds tested. The percentage of reactors was higher than expected by those conducting the work. The marked improvement in viability of chicks in the spring of 1929 proved the value

TABLE 2.—*Summary of results of testing, 1928.*

Breed	No. of Flocks	Males			Females			Males and Females		
		No. of Birds	No. of Reactors	Per Cent Birds	No. of Reactors	No. of Birds	Per Cent Reactors	No. of Birds	No. of Reactors	Per Cent Birds
*B. P. R.	90	388	25	6.44	8414	1266	15.04	8802	1291	14.66
S. C. W. L.	7	24	1	4.16	1450	120	8.27	1474	121	8.20
W. W.	2	31	2	6.45	372	129	34.67	403	131	32.50
Total	99	443	28	6.32	10236	1515	14.80	10679	1543	14.44

*B. P. R.—Barred Plymouth Rocks. S. C. W. L.—S. C. White Leghorns. W. W.—White Wyandotts.

of the test and warranted the continuance of testing work. The provincial poultry breeding policy known as the New Brunswick Accredited Flock System was accordingly amended to include as one of its requirements the annual testing of all flocks entered. Flocks having two successive negative tests were to be exempted from testing for one year if all hatching had been done at home, no custom hatching done, and no hatching eggs, day old chicks, or breeding stock purchased.

As an inducement for flock owners to have their birds tested the provincial Department of Agriculture offered in 1928 to rebate half the actual cost of testing including laboratory fees, express on blood samples and other incidental expenses. This offer has been made in each succeeding year.

The taking of blood samples has become a regular part of the routine work of officials of the Poultry Division. Most of the work is done between October 1st and December 10th, though samples have been taken in the warm weather of August and in zero weather of winter. In four years' work only one lot of less than one hundred samples has been spoiled for testing. These were frozen, presumably while being held prior to shipment by the flock owner.

In all the testing work supervised in four years by the Department of Agriculture, vials in blocks of one hundred have been used which do not require individual numbering if filled and placed in the block in proper order. Blocks are shipped to and from the laboratory in wooden cases holding two, four or six blocks. Other equipment used in taking samples consists of a folding card table with top covered with oilcloth, folding chairs, a small wooden chest similar to a carpenter's tool chest and a gasoline lantern. The table is used to hold blocks of vials, forms, leg bands, pliers, disinfectant and other equipment used while samples are being taken. The chairs are of course for the convenience of those taking the samples and the chest is to hold a supply of leg bands, absorbent cotton, pliers, lance, and other instruments and tools required. The gasoline lantern has two uses. It will provide good light if it becomes necessary to take samples after dark and if placed under the table on extremely cold days it provides heat that adds to the comfort of the workers. It is possible to take poultry blood samples without much of the above equipment but its use adds efficiency and speed to the work. The entire equipment referred to may be carried in the back seat of a car together with two or three thousand vials.

In New Brunswick the Department of Agriculture has furnished two men towards each crew engaged in taking blood samples. One man examines the birds for disqualifications and other defects, bands those passing his inspection and records their leg band numbers. The second does the actual bleeding. Each flock owner is required to supply two persons also, one to catch the birds and the other to hold them while samples are being taken. With a crew of four, working as described, from one hundred to one hundred and twenty samples are taken per hour.

TABLE 3.—*Summary of results of testing, 1929.*

Breed	No. of Flocks	Males			Females			Males and Females		
		No. of Birds	No. of Reactors	Per Cent Reactors	No. of Birds	No. of Reactors	Per Cent Reactors	No. of Birds	No. of Reactors	Per Cent Reactors
Barred Plymouth Rocks	137	1073	68	6.33	13615	1257	9.23	14688	1325	9.02
S. C. White Leghorns	9	26	1	3.84	710	42	5.91	736	43	5.84
White Wyandotts	4	6	0	0.	381	31	8.13	387	31	8.01
White Plymouth Rocks	1	1	0	0.	12	0	0.	13	0	0.
Rhode Island Reds	3	3	1	33.33	10	1	10.	13	2	15.38
Jersey Black Giants	2	1	0	0.	22	0	0.	23	0	0.
Total All Breeds	156	1110	70	6.30	14750	1331	9.02	15860	1401	8.83

TABLE 4.—*Summary of results of testing, 1930.*

Breed	No. of Flocks	Males			Females			Males and Females		
		No. of Birds	No. of Reactors	Per Cent Reactors	No. of Birds	No. of Reactors	Per Cent Reactors	No. of Birds	No. of Reactors	Per Cent Reactors
Barred Plymouth Rocks	190	1250	55	4.40	19413	1744	8.98	20663	1799	8.70
S. C. White Leghorns	15	62	2	3.22	1173	57	4.85	1235	59	4.77
White Wyandotts	5	25	6	24.	282	57	20.21	307	63	20.52
White Plymouth Rocks	3	3	0	0.	29	6	20.69	32	6	18.75
Rhode Island Reds	2	0	0	0.	54	24	44.44	54	24	44.44
Buff Orpingtons	2	1	0	0.	38	1	2.63	39	1	2.56
Jersey Black Giants	1	4	0	0.	4	0	0.	8	0	0.
Total All Breeds	218	1345	63	4.68	20993	1889	8.99	22338	1952	8.73

TABLE 5.—*Summary of results of testing, 1931.*

Breed	No. of Flocks	Males			Females			Males and Females		
		No. of Birds	No. of Reactors	Per Cent Reactors	No. of Birds	No. of Reactors	Per Cent Reactors	No. of Birds	No. of Reactors	Per Cent Reactors
Barred Plymouth Rocks	166	1720	31	1.80	19606	634	3.23	21326	665	3.11
S. C. White Leghorns	15	153	0	0.	2079	51	2.43	2250	51	2.26
White Wyandotts	6	23	0	0.	243	16	6.58	266	16	6.01
White Plymouth Rocks	1	0	0	0.	124	15	12.09	124	15	12.09
Rhode Island Reds	2	3	0	0.	36	0	0.	39	0	0.
Buff Orpingtons	1	0	0	0.	11	0	0.	11	0	0.
Jersey Black Giants	1	0	0	0.	10	1	10.00	10	1	10.00
Games	1	0	0	0.	2	0	0.	2	0	0.
Total All Breeds	193	1899	31	1.63	22129	717	3.24	24028	748	3.11

TABLE 6.—*Summary of four years testing, 1928-31.*

Breed	No. of Flocks	Males			Females			Males and Females		
		No. of Birds	No. of Reactors	Per Cent Reactors	No. of Birds	No. of Reactors	Per Cent Reactors	No. of Birds	No. of Reactors	Per Cent Reactors
1928—All Breeds	99	443	28	6.32	10236	1515	14.80	10679	1543	14.44
1929—All Breeds	156	1110	70	6.30	14750	1331	9.02	15860	1401	8.83
1930—All Breeds	218	1345	63	4.68	20993	1889	8.99	22338	1952	8.73
1931—All Breeds	193	1899	31	1.63	22129	717	3.24	24028	748	3.11
Four Year Totals	666	4797	192	4.00	68108	5452	8.00	72905	5644	7.74

Summaries of the results of testing done in New Brunswick in 1929, 1930 and 1931, comparable to those given in Table 2 for the year 1928, are given in Tables 3, 4 and 5 respectively while a summary of the four years' work is shown in Table 6. In these and following tables, where one flock owner had two or more breeds, each breed is reported as a separate and distinct flock.

Tables 2, 3, 4 and 5 are largely self-explanatory. It will be noted that in general the percentage of reactors has been notably higher in the heavy breeds than in the light breeds. This is in agreement with results reported by Biely (*5*). Where exceptions to this rule occur the number of birds of the variety tested is exceedingly small. In general the percentage of reactors has been higher among females than males. This is in agreement with results reported by Biely (*5*). With Rhode Island Reds in 1929 and White Wyandotts in 1930 the percentage of reactors among males was higher than among females but here too the number of each of these breeds tested was too small to allow much significance to be attached to the results. It is interesting to note in Table 6 that in four years' work the percentage of reactors in females was exactly twice the percentage of reacting males.

TABLE 7.—*Severity of infection, 1928.*

Per cent of Birds Reacting	Barred Rocks		S. C. White Leghorns		White Wyandotts	
	No. of Flocks	No. of Birds	No. of Flocks	No of Birds	No. of Flocks	No. of Birds
With no Reactors	25	1804				
Up to and including 5 per cent	16	1828	2	166	1	117
Over 5 per cent to 10 per cent	9	1060	2	773		
" 10 " " " 15 " "	6	783	2	352		
" 15 " " " 20 " "	2	386	1	183		
" 20 " " " 25 " "	5	851				
" 25 " " " 30 " "	7	453				
" 30 " " " 35 " "	7	525				
" 35 " " " 40 " "	3	324				
" 40 " " " 45 " "	2	261			1	286
" 45 " " " 50 " "	3	280				
" 50 " " " 55 " "	1	91				
" 55 " " " 60 " "	1	28				
" 60 " " " 65 " "	2	110				
" 65 " " " 70 " "						
" 70 " " " 75 " "						
" 75 " " " 80 " "						
" 80 " " " 85 " "						
" 85 " " " 90 " "	1	18				
" 90 " " " 95 " "						
" 95 " " " 100 " "						
Totals	90	8802	7	1474	2	403

The results shown in Tables 2, 3, 4 and 5 are for work done in a province-wide campaign. Many individual flocks were tested in each of the four years. Some, however, were tested in 1928 or 1929 and have not been since tested. Others were not tested in the first year's work but began testing at a later date. Thus the improvement in percentage of reactors

from year to year does not truly represent an improvement entirely directly due to the testing done. Many flocks which reacted severely in the first or subsequent tests have been replaced in whole or in part by stock from flocks free from infection. This replacement has materially reduced the percentage of reactors in the provincial totals. In individual flocks which have depended on annual testing rather than replacement to lower their percentage of reactors there has been decided improvement both in percentage of reactors and in viability of chicks hatched. This improvement has been greatest where reacting birds were immediately disposed of and buildings and incubators given a thorough cleaning.

Tables 7, 8, 9 and 10 show the severity of infection in the different breeds tested grouped according to the percentage of reactors present in the flocks. These tables show a very wide variation in the amount of infection in different flocks for each year testing has been done. A gratifying feature shown by these tables is the consistent increase from year to year in the number of flocks having no reactors or a low percentage of reactors. In 1928 of the 99 flocks tested 25 or 25.25% were free from reactors while in 1931 there were 100 flocks or 51.81% of the total of 193 tested that were without reactors.

The results of four years' testing for pullorum in New Brunswick indicate that the disease can be controlled but probably not entirely eradicated by a single annual test. Eradication could be much more quickly effected by the application of two or more tests yearly. It has been impossible to make a retest general in the province but some work has been done and results which compare favorably with those reported by Biely (*5*) are shown in Table 11.

Reference to a few individual flocks mentioned in Table 11 will indicate the improvement effected by the retest.

Flock 1 with 36.68% reactors in the first test and 30.33% in the retest had had such heavy chick mortality for a number of years that it had been unprofitable. The owner tried testing for pullorum as a last resort before quitting the business. Since the two tests before the hatching season of 1929 mortality has been very low. Further tests showed, in the fall of 1929, no positive and one questionable reactor among 355 birds tested; in 1930 one positive and two doubtful of 464 tested and in 1931 three positive of 546 birds tested. In this flock the entire improvement cannot be credited to the testing as some hatching eggs were purchased from a pullorum-free flock in the spring of 1929.

Flock 2 had no reactors in 1928 but evidently got infection by having eggs custom hatched by a commercial hatchery in the spring of 1929. That fall there were 36.84% reactors in the first test and 26.08% in the second. Subsequent tests have shown a decided reduction in percentage of reactors the figures being 3.67 in 1930 and .9 in 1931.

Flock 3 had no reactors in 1928 but had eggs custom hatched in 1929 and apparently infection was introduced from that source. Three tests were made in the fall of 1929 and during the succeeding winter in which the percentage of reactors was 17.33, 19.09 and 1.49 respectively. This

TABLE 8.—*Severity of infection, 1929.*

Per Cent of Birds Reacting	Barred Rocks		S. C. White Leghorns		White Wyandotts		White Rocks		Rhode Island Reds		Jersey Black Giants	
	No. of Flocks	No. of Birds	No. of Flocks	No. of Birds	No. of Flocks	No. of Birds	No. of Flocks	No. of Birds	No. of Flocks	No. of Birds	No of Flocks	No. of Birds
With no Reactors	41	3327	3	114	1	15	1	13	1	6	2	23
Up to and including 5 per cent	41	5645	2	304	2	194						
Over 5 per cent to 10 per cent	16	1793	1	39								
" 10 " " " 15 " "	11	1132	2	170								
" 15 " " " 20 " "	4	379	1	109	1	178			1	6		
" 20 " " " 25 " "	4	299										
" 25 " " " 30 " "	5	526										
" 30 " " " 35 " "	3	546										
" 35 " " " 40 " "	6	507										
" 40 " " " 45 " "	3	167										
" 45 " " " 50 " "	2	189										
" 50 " " " 55 " "	1	178										
" 55 " " " 60 " "												
" 60 " " " 65 " "												
" 65 " " " 70 " "												
" 70 " " " 75 " "												
" 75 " " " 80 " "												
" 80 " " " 85 " "												
" 85 " " " 90 " "												
" 90 " " " 95 " "									1	1		
" 95 " " " 100 " "												
Totals	137	14688	9	736	4	387	1	13	3	13	2	23

TABLE 9.—*Severity of infection, 1930.*

Per Cent of Birds Reacting	Barred Rocks		S. C. White Leghorns		White Wyandotts		White Rocks		Rhode Island Reds		Buff Orpingtons		Jersey B. Giants	
	No. of Flocks	No. of Birds	No. of Flocks	No. of Birds	No. of Flocks	No. of Birds	No. of Flocks	No. of Birds	No. of Flocks	No. of Birds	No. of Flocks	No. of Birds	No. of Flocks	No. of Birds
With no Reactors	63	4025	3	50					1	14	1	24	1	8
Up to and including 5 per cent	53	7969	9	1023										
Over 5 per cent to 10 per cent	21	2018			1	146					1	15		
" 10 " " " 15 " "	17	2698			1	44	1	17						
" 15 " " " 20 " "	10	1384	1	126	1	27	1	5						
" 20 " " " 25 " "	6	1203												
" 25 " " " 30 " "	3	192					1	10						
" 30 " " " 35 " "	3	166	1	28										
" 35 " " " 40 " "	3	137	1	8	1	47								
" 40 " " " 45 " "	2	222												
" 45 " " " 50 " "	4	271												
" 50 " " " 55 " "	2	133			1	43								
" 55 " " " 60 " "									1	40				
" 60 " " " 65 " "														
" 65 " " " 70 " "	2	217												
" 70 " " " 75 " "														
" 75 " " " 80 " "	1	28												
" 80 " " " 85 " "														
" 85 " " " 90 " "														
" 90 " " " 95 " "														
" 95 " " " 100 " "														
Totals	190	20663	15	1235	5	307	3	32	2	54	2	39	1	8

Table 10.—*Severity of infection, 1931.*

Per Cent of Birds Reacting	Barred Rocks		S. C. W. Leghorns		W. Wyandotts		White Rocks		Rhode Is. Reds		Buff Orpingtons		Jersey B. Giants		Games	
	No. of Flocks	No. of Birds	No. of Flocks	No. of Birds	No. of Flocks	No. of Birds	No. of Flocks	No. of Birds	No. of Flocks	No. of Birds	No. of Flocks	No. of Birds	No. of Flocks	No. of Birds	No. of Flocks	No. of Birds
With no Reactors	85	6850	8	686	3	75			2	39	1	11			1	2
Up to and including 5 per cent	55	9910	6	1482	1	148										
Over 5 per cent to 10 per cent	13	3233			1	29							1	10		
" 10 " " " 15 " "	4	469					1	124								
" 15 " " " 20 " "	4	360														
" 20 " " " 25 " "	1	65	1	82												
" 25 " " " 30 " "																
" 30 " " " 35 " "	2	364														
" 35 " " " 40 " "																
" 40 " " " 45 " "	2	75														
" 45 " " " 50 " "																
" 50 " " " 55 " "																
" 55 " " " 60 " "																
" 60 " " " 65 " "																
" 65 " " " 70 " "																
" 70 " " " 75 " "																
" 75 " " " 80 " "					1	14										
" 80 " " " 85 " "																
" 85 " " " 90 " "																
" 90 " " " 95 " "																
" 95 " " " 100 " "																
Totals	166	21326	15	2250	6	266	1	124	2	39	1	11	1	10	1	2

TABLE 11.—*Details of flocks receiving more than one test yearly.*

	First Test				Second Test			
Flock	Date of First Test	No. of Birds Tested	Number of Reactors	Per cent Reactors	Date of Second Test	No. of Birds Tested	Number of Reactors	Per Cent Reactors
1	Oct. 27, 1928	169	62	36.68	Feb. 15, 1929	89	27	30.33
2	Oct. 9, 1929	76	28	36.84	Feb. 7, 1930	23	6	26.08
3	Oct. 9, 1929	150	26	17.33	Nov. 28, 1930	110	*21	19.09
3					†Feb. 7, 1930	67	1	1.49
4	Oct. 14, 1929	105	28	26.66	Feb. 20, 1930	73	2	2.74
5	Nov. 8, 1929	118	17	14.40	Feb. 14, 1930	91	3	3.29
6	Nov. 8, 1929	45	10	22.22	Feb. 14, 1930	29	2	6.89
7	Nov. 12, 1929	109	24	22.01	Feb. 17, 1930	78	12	15.38
8	Nov. 26, 1929	307	37	12.05	Feb 6 1930	142	3	2.11
9	Nov. 29, 1929	467	150	32.12	Feb. 5, 1930	241	13	5.39
10	Dec. 2, 1929	124	47	37.90	Mar. 8, 1930	58	2	3.44
11	Oct. 10, 1930	479	57	11.90	Feb. 3, 1931	368	11	3.01
12	Oct. 17, 1930	358	38	10.61	Dec. 8, 1930	300	0	0.
13	Oct. 31, 1930	739	164	22.19	Dec. 2, 1930	429	13	3.03
13‡	Oct. 31, 1930	126	21	16.66	Dec. 2, 1930	95	0	0.
14	Nov. 3, 1930	47	6	12.76	Jan. 8, 1931	41	1	2.44
15	Nov. 3, 1930	93	11	11.82	Jan. 8, 1931	34	0	0.
10	Nov. 11, 1930	156	2	1.28	Jan. 23, 1931	93	0	0.
16	Nov. 13, 1930	155	21	13.54	Jan. 23, 1931	126	0	0.
17	Nov. 25, 1930	503	84	16.70	Jan. 21, 1931	309	3	.97
18	Nov. 28, 1930	110	23	20.91	Feb. 4, 1931	77	1	1.30
19	Nov. 29, 1930	214	33	15.42	Jan. 22, 1931	171	2	1.17
20	Nov. 18, 1931	78	13	16.66	Dec. 5, 1931	64	1	1.56
21	Nov. 19, 1931	284	41	14.43	Jan. 13, 1932	194	3	1.54

* Six reactors from first test included by mistake in this flock.
† Third Test.
‡ Single Comb White Leghorns. All other flocks Barred Plymouth Rocks.

is the only instance where a retest showed a higher percentage of reactors than the first test and this was accounted for by the discovery that six reactors from the first test were inadvertently left in the flock and tested the second time. In the 1930 test there were 1.8% reactors and in 1931 1.16%.

Flock 10 shows an apparent complete eradication of the disease. In the fall test of 1929 there were 37.9% reactors; in the following winter test 3.44%; in the fall of 1930 1.28% and in both the winter test of 1931 and the fall test of the same year there were none.

At the present time in New Brunswick a second test within a year is only considered where the percentage of reactors has been more than ten and where there are one hundred or more birds to be tested after reactors from the first test have been removed from the flock. In many cases, particularly where flocks are small and where the percentage of reactors has been high, the owners are advised to replace the entire flock by the purchase of hatching eggs or day old chicks from a disease-free source rather than to follow the slower method of applying repeated tests.

TABLE 12.—*Doubtful reactors.*

Year of Test	Number of Males Tested	Number of Males Doubtful	Number of Females Tested	Number of Females Doubtful	Number of Males and Females Tested	Number of Males and Females Doubtful
1928—First Test	443	0	10236	0	10679	0
1928—Second Test	1	0	88	0	89	0
1929—First Test	1110	10	14750	98	15860	108
1929—Second Test	0	0	845	14	845	14
1929—Third Test	0	0	67	1	67	1
1930—First Test	1345	1	20993	72	22338	73
1930—Second Test	76	1	1967	7	2043	8
1931—First Test	1899	0	22129	1	24028	1
1931—Second Test	1	0	257	0	258	0

In Tables 1 to 11 inclusive the word reactor is used to indicate the bird which has given positive reaction to the agglutination test. Doubtful reactors have been reported by the laboratories doing the testing and particulars regarding those encountered in four years' work are given in Table 12. In the provincial breeding policy they have been treated as positive reactors and disposed of for market purposes. While it is realized that some of these birds may not be reactors, the percentage is small and the birds scattered over the province so that the expense of a retest is not warranted.

Testing for pullorum was not undertaken in New Brunswick to furnish scientific data but as a means of lowering excessive chick mortality which threatened in its infancy the commercial hatchery business of the province. To that end it has been successful to a marked degree. All testing has been done by commercial laboratories and results have been decidely consistent.

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BUD VARIATION IN THE APPLE[1]

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Bud variation in apples was re-discovered in the New World long after it had almost been forgotten in the Old. Mention was made of bud variation in fruits by Thomas Andrew Knight (*5*) in papers published over a hundred years ago. No doubt bud sports have been occurring in the apple over a very long period of time, but it is only within the past few years that their commercial possibilities have become fully appreciated. This is due largely to the enterprise of American nurserymen, who have given extensive advertising to several bud sports of important commercial varieties. Stimulated by this publicity, apple growers in many sections of the United States and Canada have made a diligent search for bud variations, with the result that surprisingly large numbers of bud sports have been found.

Most of the known bud variations of apple have to do with colour of the fruit. This is probably due to the ease with which colour sports can be recognised. The list of varieties for which "red" sports have been reported (*1*) (*2*), now includes such important commercial sorts as: Northern Spy, Fameuse, Ben Davis, Baldwin, Duchess of Oldenburg, Gravenstein, Delicious, Rome Beauty, Winesap, Stayman Winesap, Jonathan and McIntosh. There are also well substantiated reports of bud variations affecting size, shape and russeting of fruits (*4*) also yield and size of trees (*3*) (*6*). The frequency with which bud sports of the apple were being reported and the possible influence of these sports on the trend of apple-growing made it seem desirable to undertake a comprehensive study of bud variation in the apple. Accordingly a project was started at the Dominion Experimental Station, Summerland, B.C., Canda, in 1926. The chief purpose of this investigation was to provide answers to the following questions:

1. Can superior strains of existing varieties of apples be developed by the selection and propagation of bud variations?
2. Is bud selection necessary to prevent the deterioration of existing varieties?
3. To what extent do bud sports differ from the original varieties?
4. Do colour sports differ from the original varieties in other characteristics besides colour development?

Attention has been concentrated chiefly on the study of colour sports in McIntosh and Delicious, two varieties in which bud variation seems to be especially prevalent. McIntosh is a truly Canadian apple, having originated as a seedling on the McIntosh homestead in Ontario. Un-

[1] A paper presented at the Tenth International Horticultural Congress held in Paris, France, May 30 to June 7, 1932.

[2] Superintendent.

[3] The chemical analyses reported in this paper were carried out by C. C. Strachan at the University of British Columbia in partial fulfillment of requirements for the degree of Bachelor of Science in Agriculture.

fortunately the original McIntosh tree is now dead, so that it is not possible to secure direct evidence as to whether it bore red or striped apples. However, as the full name of the variety is McIntosh Red, it seems probable that the original tree bore red rather than striped fruits. Light may be thrown on this question by the behaviour of twenty McIntosh trees planted at the Summerland Station in 1916. Careful observations during the past five years have revealed the fact that ten of these trees produce red fruits and ten produce striped fruits. Furthermore, the ten trees which produce red fruits have given rise to fifteen limb variations which bear striped apples, and the ten trees which produce striped apples have given rise to only one limb variation bearing red apples. These data are presented in tabular form below.

TABLE 1.—*Limb variations of the McIntosh apple.*

Number of trees	Colour of fruit	Number of variations	Colour of fruit
10	red	15	striped
10	striped	1	red

Possibly the data incorporated in Table I may assist geneticists to determine whether the original McIntosh tree produced red or striped apples.

Proof that there are distinct red and striped strains of McIntosh has been secured from propagation trials. Scions from trees bearing red apples and scions from trees bearing striped apples have been top-grafted on the same framework. The resulting tree produces both red fruits and striped fruits, the branches which have developed from the red strain scions bearing red apples, and the branches which have developed from the striped strain scions bearing striped apples.

The commercial advantage of the red strain lies in the fact that McIntosh are graded largely according to the percentage of their surface which is covered with solid red colour, the more highly coloured specimens commanding the greater price. To secure accurate information as to the influence of colour strain on grade, the 1930 crop from each of the twenty McIntosh trees mentioned above, totalling over 70,000 apples, was sorted into three colour grades to conform with the Canadian Government colour requirements for Extra Fancy, Fancy and C Grade McIntosh. The fruit was all picked within a two day period towards the close of the harvesting season for the McIntosh variety. The grading was carried out by a trained inspector immediately after the fruit was picked. The results secured are summarised in Table 2.

From the data presented above, it will be noted that over half the crop from the red strain trees qualified for the Extra Fancy Grade whereas only 27% of the fruit from the striped strain trees developed sufficient red colour to be classed as Extra Fancy. The commercial significance of

this difference is readily apparent when it is borne in mind that Extra Fancy McIntosh commonly command a premium of 25 cents a bushel over the Fancy Grade. The lower percentage of C grade fruits in the crop from the red strain trees is also of material importance, for many growers consider that the prices received for C grade McIntosh during the past five years have not covered the costs of production.

TABLE 2.—*Colour grading of McIntosh strains.*

Grade	Percentage of Crop in each grade	
	Striped Strain	Red Strain
Extra Fancy	27	51
Fancy	42	31
C Grade	31	18

Attention is drawn to the fact that even with the red strain trees of McIntosh, a portion of the crop failed to develop sufficient red colour to qualify for the Fancy Grade. That this may not be altogether a disadvantage will become apparent in the discussion of results secured from harvesting and storage experiments carried out with colour strains of the Delicious variety.

The Delicious was introduced to commerce only about forty years ago and there is conclusive evidence that the original tree produced striped fruits. Nevertheless over fifty variations bearing red fruit have now been reported. What appear to be four distinct red sports of Delicious have been found in British Columbia. Unfortunately evidence is lacking as to their origin, for they have appeared as individual trees in commercial orchards in the Salmon Arm, Vernon, Oyama and Winfield districts respectively. However, the appearance and behaviour of these trees indicate that they represent bud variations from the original striped Delicious.

These four Canadian strains of Delicious have been propagated on clonal root stocks at the Summerland Station. Accordingly information will soon be available as to their performance under uniform growing conditions.

In the meantime, harvesting and storage experiments have been carried out with the fruit from the original trees. For purposes of comparison a tree of the striped Delicious of similar age and vigour to the tree of the red strain was selected in each orchard. From each of these eight trees pickings were made on October 2nd, 9th, and 16th, 1930. At each picking a hundred apples were harvested from each tree, care being taken to pick specimens representative of the colour development of the crop. Although the trees are growing in widely separated districts, it was found possible, by making a 270 mile motor trip, to have one investigator harvest fruit from all the trees and transport it to the Summerland Station on the same day.

The day following each picking, the apples were graded for skin colour. Twenty specimens from each tree were tested for hardness and cut to ascertain flesh colour.

Forty apples from each tree were held in common storage and another forty were placed in cold storage at 32°F. The cold stored lots were later sent to the University of British Columbia for chemical analysis.

Pressure determinations made with a mechanical pressure tester did not reveal any significant difference in hardness between the red and striped strains grown under similar conditions. There was a marked difference, however, in time and amount of colour development. By having the same observer grade all the apples in this experiment into three classes to conform with the Canadian Government colour requirements for Extra Fancy, Fancy and C Grade Delicious, it was possible to secure comparable data. Some of the information secured in this way is presented in Table 3.

TABLE 3.—*Colour grading of Delicious strains.*

Picking Date	Percentage of Extra Fancy Grade Fruit	
	Striped Strain	Red Strains
October 2nd	5	83
October 9th	22	90
October 16th	45	94

The figures incorporated in Table 3 indicate the percentage of fruit with Extra Fancy colour harvested from the striped and red strain trees at each picking date. It will be noted that there was a very low percentage of Extra Fancy fruit harvested from the striped strain trees on October 2nd, whereas over 80% of the crop from the red strain trees had already developed sufficient red colour to qualify for the Extra Fancy grade. There was a pronounced difference in quality of colouring on the individual red strains, fruits from the Salmon Arm and Vernon trees developing a bright scarlet colour, whereas those from Oyama and Winfield became a deep mahogany red.

Most growers are well satisfied when half their crop of striped Delicious qualifies as Extra Fancy. It seems altogether probable therefore that growers are likely to pick the red strains at an earlier date than has been customary with the striped Delicious. That such a procedure may react to their disadvantage is indicated by determinations of flesh colour, quality and chemical composition.

As Delicious approach maturity on the tree, flesh colour changes from a distinct green through an almost white stage to a creamy yellow. These flesh colours are similar though not identical to Pale Chalcedony Yellow, Marguerite Yellow and Napthalene Yellow as shown in Ridgway's colour chart.

To secure information as to flesh colour, twenty apples from each picking from each tree were cut across and graded into three flesh colour classes, designated "green", "white" and "yellow". Data secured by this procedure are shown in Table 4.

TABLE 4.—*Flesh colour grading of Delicious strains.*

Picking Date	Percentage of fruit with "green" flesh colour	
	Striped strain	Red strains
October 2nd	31	25
October 9th	16	20
October 16th	7	11

From the data presented in Table 4, it is apparent that a fairly high percentage of the fruit picked on October 2nd had "green" flesh colour. There were fewer "green" fleshed fruits in the October 9th picking and fewer still in the picking made on October 16th.

In order to secure evidence regarding the correlation of flesh colour and skin colour, the same fruits which were cut across to determine flesh colour were also graded for skin colour. Some of the data recorded are summarised in Table 5.

TABLE 5.—*Correlation of skin colour and flesh colour.*

Flesh Colour	Percentage of Extra Fancy Fruit	
	Striped strain	Red Strains
Green	0	28
White	32	32
Yellow	68	40

From Table 5 it is evident that there were no "green" fleshed fruits in the striped Delicious carrying sufficient red colour to qualify for the Extra Fancy Grade, whereas 28% of the Extra Fancy fruit of the red strains had "green" flesh colour. In other words, grading for red colour eliminated the "green" fleshed fruits from the Extra Fancy grade in the case of the striped Delicious but not in the case of the red strains.

The significance of the fact that the red strains develop red skin colour before their flesh colour has progressed to the "white" or "yellow" stages was revealed by quality determinations made during the storage period. While the "green" flesh colour tends to bleach out somewhat after the fruit is picked, it was nevertheless found possible to grade stored samples into "green", "white" and "yellow" flesh colours on November 14th. Quality, as applied to an apple, is a very comprehensive term. Flavour, texture, aroma, sugar content, and acidity are all involved in that combination of

characteristics called quality. As the tastes of individual consumers differ, it is not easy to devise a satisfactory scale of quality. However, a record of the comparative excellence of individual specimens was secured by classifying them as "good", "fair" and "poor". Several specimens from each picking from each tree were sampled by the same observer. It was found that the percentage of "good" quality fruit was higher in the second picking than in the first and higher in the third than in the second. However, there was a wide range of quality even in apples picked from the same tree on the same day, especially in the first picking. The correlation between flesh colour and quality on the other hand was found to be very close, most of the specimens having "green" flesh colour being classed as "poor" in quality. This suggests that early picking of the red strains may result in a high percentage of fruit with Extra Fancy colour requirements but poor dessert quality.

Analysis for sugar provided further evidence of the immaturity of highly coloured fruit picked from three of the red strains on October 2nd. Table 6 shows the total percentage of sugar in fruit from each of the red and striped strains picked on October 2nd. The C Grade fruit was eliminated from the samples used for analysis.

TABLE 6.—*Sugar content of Delicious strains*

Source of fruit	Percentage of sugar in fruit	
	Striped strain	Red strains
Salmon Arm	14.4	15.5
Vernon	12.4	10.3
Oyama	11.8	10.7
Winfield	12.0	11.0

As is indicated in Table 6, the fruit picked from the Salmon Arm trees on October 2nd had a higher sugar content than that picked from the other six trees on the same date. In this connection it may be well to mention that according to flesh colour determinations the Salmon Arm trees matured their fruit earlier than the others, and of the two Salmon Arm trees, the red strain matured its crop before the striped strain. There were comparatively few "green" fleshed fruits in the sample picked from the Salmon Arm striped strain tree, and no "green" fleshed fruits whatever in the sample picked from the Salmon Arm red strain tree on October 2nd. This may account for the fact that the apples from the red strain tree had a higher sugar content than those from the striped strain tree.

In the case of the Vernon, Oyama and Winfield trees, analysis of apples picked on October 2nd indicated that the red strain fruit contained appreciably less sugar than the striped strain fruit. This is probably due to the fact that elimination of C grade fruit from the samples used for analysis removed the "green" fleshed apples from the striped but not from the red strains. Data substantiating this statement are to be found in Table 7.

The data presented in Table 7 were secured by analysing fruit having "green", "white" and "yellow" flesh colour. It will be noted that there was no material difference in sugar content between red and striped strain fruit of the same flesh colour grade. On the other hand, fruit of "white" flesh colour had significantly greater sugar content than fruit of "green" flesh colour, and fruit of "yellow" flesh colour had significantly greater sugar content than fruit of "white" flesh colour.

TABLE 7.—*Sugar content of flesh colour grades.*

Flesh Colour Grade	Percentage of fruit	
	Striped strain	Red strain
Green	12.5	12.4
White	13.1	12.9
Yellow	13.5	13.9

The data presented in the foregoing tables indicate that there are red strains of Delicious which produce a much higher percentage of Extra Fancy coloured fruit than the original striped variety. It is also apparent, however, that this early development of red colour may not be altogether an advantage. In the past, red colour has provided a fairly reliable criterion of the quality of the fruit. The fact that high colour on the red strains is not necessarily accompanied by development of sugar and other characteristics which enter into the constitution of a high quality apple may react against the popularity of the variety. Accordingly it is imperative that special precautions be taken to harvest the red strains at the proper stage of maturity to ensure maximum quality.

Many more years of investigation will undoubtedly be required to ascertain the true value of bud variation as a means of improving the apple. However, sufficient progress has already been made to justify a thorough search for bud sports. Furthermore, it is evident that any bud variations which are found must be subjected to careful propagation, harvesting and storage trials to ascertain whether they represent a real improvement on the original variety.

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SMOOTH-AWNED WHEAT: INHERITANCE OF BARBING AND AWN COLOUR[1]

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Introduction

Smooth-awned barleys have been known for a long time and varieties with good agronomic characters have been developed quite recently by crossing. The smooth-awned character is of considerable economic importance. Not only are the rough-awned varieties disagreeable to handle, but they become a source of danger to live stock since the awn frequently becomes buried in the throat tissues of the animals.

The smooth-awned character in wheat has only recently been reported. Available literature reveals only two references, Flaksberger (*1*) and Sigfusson (*3*), both published in 1929. Flaksberger states that his plants were discovered simultaneously in different places by his collaborators in 1928 and in 1927. E. Palmova discovered forms the awns of which were only slightly scabrous in a sample from Tunisia. Among the plants discovered, some had slightly scabrous awns, while others had awns with the lower half smooth and the upper half slightly scabrous. Mention is also made of several plants, the main tillers of which produced smooth awns and the late tillers slightly scabrous awns. No claim is made for the discovery of plants with awns entirely smooth, yet, this discovery in wheat is considered as a parallel case to the smooth-awned barley varieties.

Sigfusson (*3*) reports the discovery of several smooth-awned plants found in 1928 in a line selected from a Marquis × Iumillo cross. Several plants were found with awns entirely smooth throughout their whole length. The writer has since subjected the smooth-awned plants to a progeny test and found them to breed true for this character. A brief description of the origin of the smooth-awned wheat is given below.

Origin and Description

In 1928 the writer found several smooth-awned plants in row S-24-60E_3 in the wheat nursery. This row descended from strain II-15-55, a Marquis × Iumilla cross made by Dr. H. K. Hayes of Minnesota in 1915 and supplied to the Brandon Experimental Farm in 1922. The number of selections made from 1922 to 1928 is shown below:

1922-24	1925 Head row	1926 Head row	1927 Head row	1928 bulk Seed
II-15-55	S-24-60	S-24-60E	S-24-60E_3	S-24-60E_3

Strain II-15-55, a durum × vugare cross, is vulgare-like in appearance but is more resistant to stem rust than the Marquis parent. Several head selections were made in 1924, in an attempt to obtain strains combining good milling value with a high degree of rust resistance.

[1]Contribution from the Department of Agriculture, Experimental Farms Branch.
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S-24-60, selected in 1924, had awns of normal length and hard (not brittle) red ovate kernels. This plant produced in 1925 bearded plants which segregated for awn colour and one plant with short apical awns which was given the number S-24-60E. This plant proved heterozygous for awned character in 1926, and produced some plants which were quite durum-like in appearance. This line was considered of no value from the standpoint of selecting a breadmaking wheat, but owing to the appearance of durum characters, three head selections were made for further study. One of these, S-24-60E_3, bred true for the bearded character in 1927, but segregated for colour of awn. The kernels were amber coloured and flinty but in shape they resembled common wheat more closely than durum. The head-row was harvested in bulk in 1927 and a random sample of the seed sown in 1928, during which year the smooth-awned plants were noticed. This row contained approximately 400 plants, most of which were rough-awned, though they appeared to vary in degree of scabridity. About 40 plants exhibited a high degree of smoothness of awn. Some of these had awns very slightly scabrous and a few had awns entirely smooth.

When examined under the microscope the awns appear cylindrical from their beaked apex to the base. The rough awns have short spiny barbs near the base and longer, irregularly scattered barbs near the tip (See Figure 2). In the smooth-awned plants the upper half of the awns are smooth, while a few rudimentary blunt barblets may be found near the base (See Figure 3). In the plants described as having slightly scabrous awns, the upper half of the awn is smooth and feels velvety but a few short barbs may be found near the base. Since it is very difficult to distinguish between the two classes of smooth-awned plants, all plants having awns which are nearly smooth are classed as smooth-awned plants in this publication.

Experimental Procedure

In general, the procedure consisted of growing head selections of several of the plants from the material in which the smooth-awned plants were found in 1928. Some of these lines segregated for barbing and awn colour in the following year while others gave uniform progeny with respect to these characters. A similar procedure was followed in 1929, except that the plants selected came from lines with known segregation or from true breeding lines. These lines were sown in 1930, but as the rainfall was very heavy that season, many of the plants lodged and the awn colour was poorly developed, making the plants difficult to classify.

The awn colour being well developed in 1929, further selections were made from 23 families and sown in 1931. Of these families, 9 segregated for awn colour and 11 for barbing, while 3 families segregated for both. In addition, selections were made from 6 families which had bred true for barbing and awn colour in 1929.

Experimental Results

ROUGH VS. SMOOTH-AWN

Heads selected at random from two families which bred true for black and smooth awns respectively in 1929, also bred true for these characters

in 1931. Similar results were obtained from a random selection from two white, smooth families in 1929. Family 46 R_2, classified as breeding true for black and rough awns in 1929 was found homozygous for these characters in 1931. Similarly, family 11 R_2 bred true for white and rough awn.

Out of 11 families segregating for rough versus smooth awn, 132 rough plants or lines were selected for further study in 1931. Of these lines 94 proved heterozygous for barbing and 38 bred true for roughness. The deviations from the theoretical 2:1 ratio, assuming one main factor difference, is 6 $\pm$ 3.61 which is only 1.7 times greater than the probable error.

The 94 segregating lines produced 1953 rough-awned plants and 605 smooth. The deviation from the theoretical 3:1 ratio is 34.5 $\pm$ 14.8

Summating the 94 segregating lines and fitting the result to a theoretical 3:1 ratio, the χ^2 was found to be 2.48 and the value of P about .12, which shows that a deviation as great or greater than the one obtained may be expected 12 times out of 100 trails. While these results appear significant, the summation of results may lead to erroneous conclusions. A χ^2 has therefore been calculated for each family where the observed frequencies of segregating lines are fitted to frequencies based on a 3:1 ratio (Table 1).

TABLE 1.—*Summation of individual χ^2 for segregating lines within each family*

Family No.	Number of lines segregating for rough vs. smooth awn	Degrees of Freedom	Summated χ^2	P
$41R_2$	10	10	8.3518	.50
$10R_2$	8	8	5.8624	.55
$13R_1$	12	12	6.2691	.85
$1R_2$	7	7	5.5071	.48
$22R_2$	11	11	15.1181	.128
$27R_2$	5	5	2.5340	.6
$49R_2$	7	7	12.4167	.054
$5R_1$	10	10	4.5227	.87
$19R_2$	9	9	10.0987	.31
$48R_2$	10	10	9.6717	.37
$52R_2$	5	5	1.3452	.84

Since the distribution of the P values centre around .5 and none is smaller than .05, it may be taken for granted that the segregation for rough vs. smooth awn within any one family does not differ significantly from that in any other, and that all families constitute a satisfactory agreement to a 3:1 ratio.

A method has been devised by Kirk and Immer (*2*) to test the agreement between the observed ratios for individual lines with that expected on the basis of a given genetic hypothesis. Each individual line was tested by the χ^2 method and the same goodness of fit test was applied to the entire group. The observed values of χ^2 are distributed among the classes bounded by values given in the χ^2 table under $n = 1$.

TABLE 2.—*Test of agreement between observed and expected class frequencies applied to 94 lines on the hypothesis of a 3:1 ratio for rough vs. smooth awn.*

χ^2	P	C Expected*	O Observed	O-C	$(O-C)^2$	$\frac{(O-C)^2}{C}$
.0000	1.00					
		.94	3	−1.70	2.89	.6149
.0002	.99					
		.94	0			
.0006	.98					
		2.82	0			
.0039	.95					
		4.70	9	4.3	18.49	3.9340
.0158	.90					
		9.4	10	.6	.36	.0382
.0642	.80					
		9.4	9	−.4	.16	.0170
.148	.70					
		18.8	19	−.2	.04	.0021
.455	.50					
		18.8	21	2.2	4.84	.2574
1.074	.30					
		9.4	6	−3.4	11.56	1.2298
1.642	.20					
		9.4	10	.6	.36	.0384
2.706	.10					
		4.70	2	−2.7	7.29	1.5510
3.841	.05					
		2.82	4	1.18	1.39	.4937
5.412	.02					
		.94	0			
6.635	.01					
		.94	1	−.88	.77	.4119
Total		94	94			
$\chi^2 = 8.5882$		n = 10		P = .47		

* Found by multiplying the total number of families by the difference in the P values immediately above and below the particular value of C to be obtained.

It is quite evident from the above table that the observed values of χ^2 do not differ significantly from the expected values and hence give no indication that the single factor hypothesis is incorrect. A few families with a high χ^2 may be expected, but an excessively large number of these would suggest that the plants might be genetically different and, at least, that further proof was desirable before a definite statement regarding the inheritance of barbing could be given.

It may then be said that the lines which gave somewhat aberrant ratios, and consequently a high χ^2, are not genetically different from those which gave normal ratios for the character rough vs. smooth awn.

BLACK VS. WHITE AWN

Out of 9 families which segregated for black and white awn colour in 1929, irrespective of barbing, 104 black-awned plants were selected for seeding in 1931. Of these plants 37 bred true for the black awn colour and 67 segregated for black vs. white awn. The deviation from a theoretical 1:2 ratio is only 2.3 which is less than its probable error of 3.21.

The 67 segregating lines produced 1599 plants. Of these, 1202 were black-awned and 397 had white awns. The deviation from a 3:1 ratio is 2.8 ± 11.67 which indicates that a single factor is responsible for the black colour of awn.

As a further proof of the single factor hypothesis, a separate χ^2 was obtained for each of the 67 lines on the basis of 3:1 ratio. The χ^2 of all lines within each of the 9 families were then summated as in Table 1. The corresponding values of P were in all cases higher than .05, indicating a satisfactory fit to a 3:1 ratio and that none of the families was genetically different with respect to awn colour.

The test developed by Kirk and Immer (*2*) comparing the distribution of χ^2 with the expected ratio was also applied.

TABLE 3.—*Test of agreement between observed and expected class frequencies applied to 67 lines on the hypothesis of a 3:1 ratio for black vs. white awn colour.*

χ^2	P	C Expected	O Observed	O-C	$(O-C)^2$	$\frac{(O-C)^2}{C}$
.0000	1.00					
		.67	2	−1.65	2.7225	.8126
.0002	.99					
		.67	0			
.0006	.98					
		2.01	0			
.0039	.95					
		3.35	7	3.65	13.3225	3.9768
.0158	.90					
		6.7	6	−.70	.4900	.0073
.0642	.80					
		6.7	7	.3	.0900	.0132
.148	.70					
		13.4	19	5.6	31.3600	2.3402
.455	.50					
		13.4	14	−.4	.1600	.0119
1.074	.30					
		6.7	4	−2.7	7.29	1.0880
1.642	.20					
		6.7	6	−.7	.49	.0731
2.706	.10					
		3.35	1	−2.35	5.5225	1.6485
3.841	.05					
		2.01	1	−1.01	1.0201	.5075
5.412	.02					
		.67	0			
6.635	.01					
		.67	1	− .34	.1156	.0862
Total		67	67			
$\chi^2 = 10.5653$			$n = 10$		$P = .31$	

The above table further emphasizes the fact that black and white awn colour are differentiated by one factor.

LINKAGE RELATIONS

Families $1R_2$, $13R_1$, and $22R_2$ segregated in 1929, both for barbing and colour of awn. Seventy-six black and rough-awned plants were

selected to study linkage relations in 1931. On the basis of independent inheritance, 11 of these lines would be expected to segregate for both characters. Actually 9 of these lines proved heterozygous and produced 177 plants. The distribution of these was as follows:

Black rough	Black smooth	White rough	White smooth	Total
93	29	42	13	177

Owing to the drought in the early part of 1931, the germination of seed was poor. Some plants germinated and succumbed before maturity due to the combined effect of drought and disease. All dead plants were discarded as they could not be accurately classified. The result is a smaller number of plants than expected and entirely too small to attempt to establish linkage relations.

The segregation obtained in the same three families in 1930 by sowing black and rough-awned plants from segregating families is as follows:

Black rough	Black smooth	White rough	White smooth	Total
155	55	59	18	287

The total number of plants produced by the segregating lines for the two years is 464, which number is large enough to determine linkage relations. A separate χ^2 was calculated for each of the segregating lines in 1929 and 1931 and fitted to a corrected 9:3:3:1 ratio according to Collins' method. The results for each year were summated and are presented below (Table 4).

TABLE 4.—*Summations of χ^2 in lines segregating for colour and roughness of awn in 1929 and 1931.*

Year	Number of Segregating Lines	Number of Plants	Degrees of Freedom	χ^2	P
1929	10	287	10	9.4602	.39
1931	9	177	9	5.3338	.72

The above table gives no indication, whatever, of linkage relations between barbing and awn colour and despite the relatively small number of plants it is safe to say that the above characters are independently inherited.

Discussion

The subject of smooth-awned wheat is interesting in view of the possibility of combining this character, by crossing, with other characters of agronomic value, and its economic importance should such a combination be obtained. The smooth-awned wheat discussed in this paper resembles durum wheat more than vulgare, but differs from it in certain important characters. Durum varieties in general have tall and weak straw. Smooth-awn has stiffer straw and much shorter. The kernels of smooth-awn are ovate in shape and very brittle, while durum kernels are much longer and somewhat less brittle. Both have amber coloured

kernels. The smooth-awned wheat also differs from durum in having much shorter awns and greater susceptibility to rust. Some families in the smooth-awned wheat produce many shrivelled kernels. Sterility is also a characteristic, in the sense that many plants die at different stages between emergence and maturity. Whether this apparent sterility is due to chromosomal incompatibility, or to its greater susceptibility to disease, is not known.

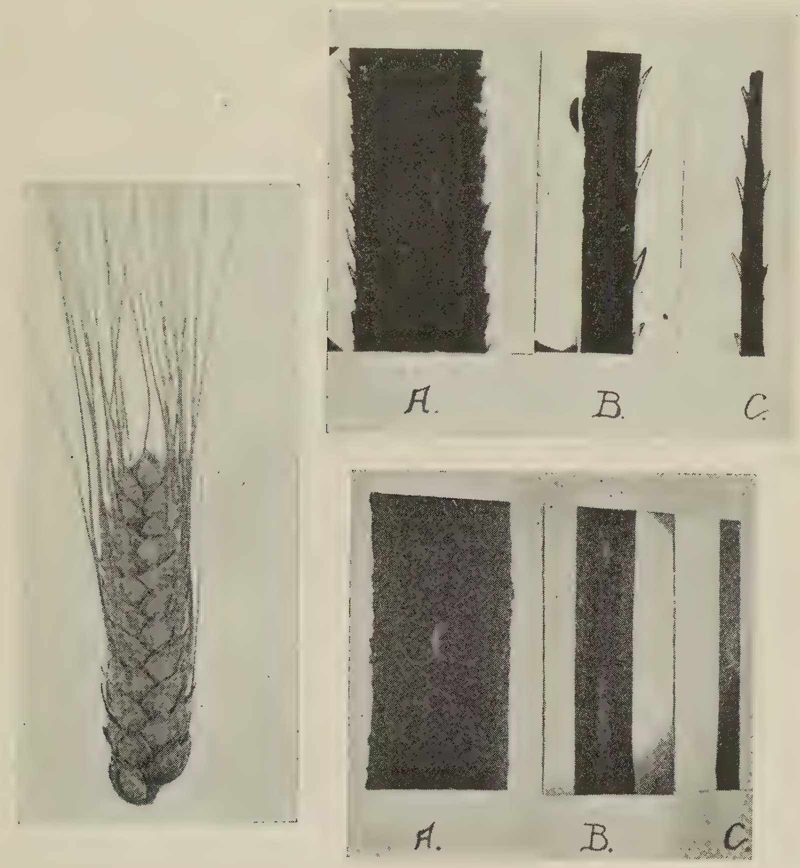

PLATE I.

Left—Figure 1. A typical smooth-awned head.
Upper right—Figure 2. Rough awn. A-base; B-centre; C-tip.
Lower right—Figure 3. Smooth awn. A-base; B-centre; C-tip.

The stem variety from which the smooth-awned wheat arose is not considered pure for all morphological characters, but all plants are awned and vulgare-like in appearance. The sudden appearance of an awnless plant in 1926 indicates a natural cross in 1925. This plant segregated in 1927 and gave rise to plants with durum characters which suggests that the male parent had durum characters but no awns. This is entirely possible since a few bald, durum-like plants have been noticed from time to time in other segregating material in the nursery. Undoubtedly, a

natural cross took place in 1925 as indicated by the appearance of a single awnless plant in 1926, but this does not account for the appearance of the smooth-awned character. A gene mutation, simultaneous with, or prior to, the natural cross might constitute a satisfactory explanation. The fact that smooth-awned plants were first noticed in 1928, does not prove that they did not exist in 1927. The parent plant S-24-60E_3 selected in 1926, was not smooth-awned but may have been heterozygous for this character.

Dr .W. P. Thompson, Professor of Biology, University of Saskatchewan, kindly consented to make chromosome counts on this wheat, and consequently, heads representing four families were sent to him in 1931. Dr. Thompson found fourteen haploid chromosomes in the plants examined and no evidence of lagging chromosomes. The cytological evidence does not indicate that a natural cross took place, neither does it disprove it. He furthermore states that the plants examined may have been either a pure race or the segregates of a cross which had become normal cytologically, since, in such a cross, a large proportion of the durum-like segregates are cytologically regular even in the second generation. If a natural cross had taken place, a cytological examination of a large number of F_2 plants would give the information desired. Unfortunately no seed is available of the segregating material found in 1928.

The rough-awned families obtained from S-24-60E_3 appear to be slightly less rough than the durum variety Mindum and perhaps slightly rougher than Kubanka. The original material differed in degree of scabridity and apparently consisted of four phenotypic classes i.e., rough, near-rough, near-smooth and smooth, with a clear line of demaracation between the near-rough and near-smooth classes. It was therefore thought that two factors were responsible for the rough-awned conditions.

It was found, however, that the rough-awned plants in general bred true for roughness, while the near-rough plants were heterozygous, thus approaching a 1:2:1 ratio. Since it is not possible to distinguish between the homozygous rough and the heterozygous rough classes with any degree of accuracy these classes have been combined.

Similarly, it was found impossible to distinguish between the near-smooth and smooth classes without the aid of a microscope and all such plants are classified as smooth. There is no question, however, that at least one auxiliary factor is operating in addition to the major factor for roughness. This auxiliary factor is responsible for the fine and scattered barbs on the lower half of the awn in the near-smooth plants. The near-smooth plants, when fully ripe, feel smooth but on the late, green tillers, the fine barbing is more apparent. Genetically, however, they would be alike. Flaksberger (*1*) describes plants having both smooth and slightly scabrous awns, on the same plant. It is likely that this condition is more apparent than real, being due to difference in maturity and that in reality these plants are near-smooth and homozygous for the minor factor for roughness.

The author recently had an opportunity to examine for barbing some of Flaksberger's plants. The seed was supplied by Dr. P. S. Hudson, School of Agriculture, Cambridge, to Dr. C. H. Goulden, Dominion Rust

Research Laboratory, Winnipeg. The awns examined were covered with short spiny barbs from tip to base and were slightly rougher than the plants classed as near-smooth in this article.

The black-awned character, as in barley, does not appear until a few days before maturity and hence immature plants are difficult to classify; furthermore, in rainy seasons, this character is not well developed. Classification in 1931 was not difficult and with the large number of plants examined, there is no doubt that the awn colour is due to only one factor.

While the number of plants segregating for both roughness and colour of awn is not as large as would be desirable, there is no evidence to indicate any linkage relations and it seems fairly definite that these characters are independently inherited.

Summary

1. The history of smooth-awned wheat is fully discussed and available literature citations given regarding the discovery of smoothness of awn in wheat elsewhere.

2. Selections were made from the original segregating material in order to establish pure lines, as well as lines with known segregation.

3. The characters studied are black vs. white awn colour and rough vs. smooth awn.

4. Colour of awn was found to be due to one factor and inherited in a 3:1 ratio, black being dominant.

5. Roughness of awn is due to one major factor. At least one auxiliary factor is also thought to be present, but its effect is not large enough to give a clear distinction between the phenotypic classes.

6. The factors for awn colour and roughness are independently inherited.

7. The cytological evidence given neither proves nor disproves that a natural cross has taken place in the early history of this wheat.

8. The plants examined were found to be cytologically normal and possessed fourteen chromosomes in the haploid stage and there was no evidence of lagging chromosomes.

9. The theory of a natural cross, as well as of a gene mutation, is advanced to explain the origin of the smooth-awned character.

Acknowledgements

Dr. K. W. Neatby, Cereal Specialist, Dominion Rust Research Laboratory, Winnipeg, has given invaluable advice and criticism in conection with the interpretation of results and arrangement of the text.

Dr. G. F. H. Buckley, Agrostologist, at the Brandon Experimental Farm, has also given freely of his time. This assistance is gratefully acknowledged.

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TRANSMISSION OF STREAK AND MOSAIC DISEASES OF TOMATO THROUGH SEED[1]

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[Received for publication June 8, 1932]

In the Twenty-fifth Annual Report of the Ontario Vegetable Growers, 1929 (*1*), the senior author pointed out the possibility of streak of tomato being seed-borne, and gave the results of a test which demonstrated transmission of the disease through seed. Since then additional evidence of seed transmission has been obtained and is recorded here.

By streak we refer to that disease of tomatoes which is common in greenhouses in Ontario and Quebec and which has been proved to be of a virus nature by Berkeley (*2*) and Vanterpool (*11*) respectively for the above provinces. This same disease, or one closely related to it is common in the United States, England and Australia.

Seed transmission of virus diseases has been demonstrated in a number of different plants. Reddick and Stewart (*10*), Burkholder and Muller (*4*), Pierce and Hungerford (*9*), and Nelson (*7*) have been successful in showing that mosaic of the common bean is transmitted through seed. Newhall (*8*) obtained up to 8% seed transmission of mosaic of lettuce; Doolittle and Gilbert (*6*) have submitted evidence of seed transmission of wild cucumber mosaic; Dickson (*5*) has published positive results of seed transmission of mosaic for various leguminous crops. Recently Bewley and Corbett (*3*) have submitted positive evidence of seed transmission of tomato and cucumber mosaics.

It is to be noted in all cases of seed transmission of virus diseases so far recorded, that the percentage of infection is not high, varying for the most part from 2 to 50%. The case of mosaic and streak of tomato is no exception. Though the authors have obtained as high as 66.6% seed transmission with streak and mosaic, such cases are rare. Out of five inoculation tests, using the crushed embryos from "streak" seed as inoculum, three tests gave negative results, while two gave positive. Therefore seed from "streak" fruits sometimes does, and sometimes does not, produce streak but we herein report definite evidence that streak can be, and often is, carried in the embryo of the seed and hence seed from streak plants should never be used for planting purposes.

Plan of Experiments.

The plan followed in these tests was to select seed, on the unit basis, from diseased or healthy plants as the case might be, and grow this seed under outdoor and glasshouse conditions. In the case of the earlier tests no special precautionary measures were taken to eliminate spread by means of insects. However, after preliminary trials indicated that mosaic and streak of tomato were sometimes seed borne, tests were then carried out under more controlled conditions. The ventilators of the glasshouse were covered with cheesecloth, making the house as insect-proof as possible and, in addition, the house was fumigated weekly. Special attention was also paid to eliminating possi-

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[2] Senior Plant Pathologist in charge and Plant Disease Investigator respectively.

bilities of mechanical spread while the tomatoes were being cultivated, watered, pruned, etc.

In addition to testing the seed by planting, a series of direct inoculations of healthy tomato plants with the crushed embryos from seed taken from mosaic or streak plants was also attempted. The seed was surface-sterilized with mercuric chloride and placed in moist chambers until germination was initiated. The embryos were then dissected from the seed under aseptic conditions, crushed with a little distilled water in a mortar, and inoculated directly into healthy tomato plants.

Throughout this paper mosaic seed refers to seed that has been specially selected from mosaic plants; likewise streak seed is seed that has originated from streak plants, while healthy seed designates seed that has been selected on the unit basis from healthy plants. Commercial seed refers to seed that was purchased from a seedsman.

Experimental Evidence of Seed Infection of Tomato Mosaic.

The first tests of seed transmission were carried out under field conditions on rather a large scale and therefore the plants were not protected in any way. Under such conditions it is only to be expected that some mosaic would show up in the plants from healthy seed but the much larger percentage of mosaic and streak occurring in the plants from commercial, mosaic or streak seed as noted in Table 1 below, is, to say the least, suggestive of seed transmission. It is also to be noted that the so-called healthy seed used in this experiment

Table 1.—*Field tests of seed from various sources.*

Variety	No. of plants	Percent mosaic	Percent streak
Grand Rapids (Healthy)	92	10.8	0.0
Grand Rapids (Healthy)	53	13.2	0.0
Grand Rapids (Healthy)	99	2.0	0.0
Grand Rapids (Healthy)	43	2.1	0.0
Blair's Forcing (Commercial)	158	32.2	15.6
Carter's Sunrise (Commercial)	91	12.0	7.6
Lloyd's Forcing (Commercial)	153	35.9	7.2
Grand Rapids (Mosaic)	98	14.2	0.0
Grand Rapids (Streak)	132	15.9	0.7
Grand Rapids (Streak)	161	27.2	31.3
Grand Rapids (Mosaic)	171	4.0	28.5

The following varieties were tested under controlled glasshouse conditions.

Table 2.—*Test of healthy and mosaic seed.*

Source of Seed	No. of plants	Percent mosaic	Percent streak
Grand Rapids (Mosaic)	50	4.0	0.0
Grand Rapids (Commercial)	50	7.0	0.0
Grand Rapids (Healthy)	50	0.0	0.0
Lloyd's Forcing (Mosaic)	50	8.0	2.0
Globe (Mosaic)	50	12.0	4.0
Grand Rapids (Healthy)	50	0.0	0.0
Grand Rapids (Mosaic)	6	0.0	33.33
Grand Rapids (Healthy)	25	0.0	0.0
Grand Rapids (Mosaic)	19	10.0	0.0

Note: Plants affected with streak also showed mosaic mottling.

was from our first selection and therefore may not have been entirely free from mosaic.

These results show definitely not only that mosaic can be transmitted through the seed, as has already been established, by Bewley and Corbett (*3*), but they also demonstrate that good control of mosaic can be effected by use of clean seed as is shown in lots Nos. 3, 6 and 8 of the above table.

Although this evidence unquestionably supports the view that mosaic may be seed borne, it should be clearly understood that the regularity with which this occurs is, to say the least, uncertain. During the past four years many trials with mosaic and streak seed have given negative results and in those cases where mosaic or streak has occurred, the symptoms were often not apparent until the second truss was forming. This delay in appearance of symptoms may partially account for the negative results of seed transmission recorded in the literature.

Inoculations with Embryos from Mosaic and Streak Seed.

The expressed and crushed embryos from mosaic and streak seed were used to inoculate healthy Grand Rapids tomatoes of our own selection. Many of these inoculations gave negative results, while high percentages of infection were obtained in other cases. Using embryos from streak seed negative results were obtained three times and positive results twice. In the case of mosaic seed, many negative results have also been obtained, but, on the other hand, as high as 66.6% infection has been obtained, showing definitely that mosaic may be carried in the seed. It is interesting to note that in one case the symptoms produced by inoculating healthy plants with the embryos from streak seed showed no mosaic mottling whatever, but consisted entirely of the necrotic lesions associated with streak. Figures 1, 2, and 3 show streak symptoms resulting from inoculations with the crushed embryos from streak seed.

Inoculations with Crushed Embryos from Streak Seed.

In one test 12 healthy Grand Rapids plants of our stock No. 51 were inoculated with the embryos from streak seed and after nineteen days 8 plants, i.e. 66.6%, showed definite streak symptoms on leaves, stems and fruits, but no mosaic mottling was apparent, except on one plant. As a check on these inoculations, 50 uninoculated healthy Grand Rapids plants of our stock No. 51 were maintained in the same section of the greenhouse and at the end of the experiment not a single plant showed any signs of mosaic or streak.

In another test 20 healthy Grand Rapids plants of our stock No. 44 were inoculated with the embryos from mosaic and streak seed and after twenty-three days 4 plants showed mosaic symptoms and 3 showed very mild streak symptoms. In this case the 22 uninoculated check plants of healthy Grand Rapids stock No. 44 remained healthy throughout the experiment.

Description of Plate I. on opposite page.

Figure 1. Streak symptoms on stalk, petioles and leaves resulting from inoculation with embryos from streak seeds. *(Photo by J. K. Richardson)*

Figure 2. Streak symptoms on leaves resulting from inoculation with expressed embryos from streak seed. *(Photo by J. K. Richardson)*

Figure 3. Streak symptoms on fruit resulting from inoculation with the embryos from streak seeds.

Figure 1.

Figure 2.

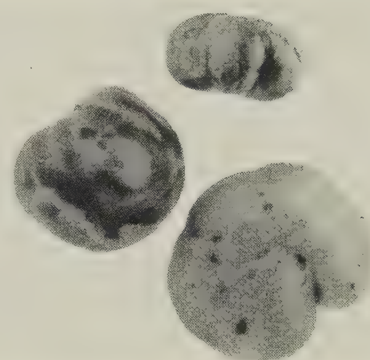

Figure 3.

Plate I. See foot of opposite page for explanation.

Inoculations with Crushed Embryos from Mosaic Seed.

In the case of inoculations with embryos from mosaic seed similar results have been obtained. In one experiment 66.6% mosaic was obtained, with no necrotic lesions whatever, and 22 healthy check plants of the same parentage remained healthy. As a further check 5 healthy plants were inoculated with the crushed embryos from healthy Grand Rapids seed and in no case did mosaic or streak appear. In other words, when healthy tomato plants were inoculated with the embryos from mosaic seed, mosaic symptoms were produced, while the embryos from healthy seed produced no symptoms whatever.

The "streak" and "mosaic" which resulted from inoculations with embryos from mosaic and streak seed has been proved by inoculation tests to be capable of producing mosaic or streak in healthy plants and is, therefore, contagious in nature and apparently similar to our common streak and mosaic.

These results clearly show that the embryos from mosaic or streak seed may contain the virus of mosaic or streak and thus mosaic and streak may be transmitted through the seed.

In view of these findings it is recommended that seed should be selected from plants free from mosaic or streak. If seed is selected in this way and precautions are taken to prevent infection of the resulting plants from insects, soil or mechanical agencies, satisfactory control of both mosaic and streak should be obtained.

Since the importance of clean, healthy seed in mosaic and streak control has been realized, we have grown in our experimental houses five successive crops of tomatoes without a single streak or mosaic plant. Previous to obtaining this healthy stock our crops always showed considerable mosaic and some streak. This evidence therefore demonstrates that not only are mosaic and streak seed borne, but that in addition, both these diseases can be satisfactorily controlled by the use of clean seed.

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RESUME DES ARTICLES PUBLIES EN ANGLAIS DANS CE NUMERO

HYBRIDATION DE *Puccinia graminis tritici* AVEC *Puccinia graminis secalis* ET *Puccinia graminis agrostidis.* T. Johnson, M. Newton et A. M. Brown, Laboratoire fédéral de Recherches sur la Rouille, Winnipeg, Man.

Des croisements ont été effectués entre *Puccinia graminis tritici* et *Puccinia graminis secalis.* Quatre formes physiologiques ont été isolées dès la première génération résultant de ces croisements. Les propriétés pathogènes de ces diverses formes indiquent qu'elles sont des hybrides véritables entre les deux races physiologiques. Ces quatre formes, portant les numéros 70, 104, 111 et 112, ont une virulence faible pour la plupart des variétés de blé et pour le seigle, mais attaquent les variétés d'orge sensiblement de la même façon que les formes parentes. Nombres de croisements entre *P. graminis tritici* et *P. graminis agrostidis* ont été essayés. Il ne s'est pas formé d'oecidies hybrides dans aucune des pustules haploïdes *d'agrostidis* auxquelles on a appliqué du nectar de *tritici* mais des oecidies d'origine hybride ont été formées dans l'une des pustules haploïdes de *tritici* auxquelles on a appliqué du nectar *d'agrostidis.* La difficulté que l'on éprouve à obtenir des oecidies hybrides suggère une interstérilité entre ces deux races physiologiques. Les oecidies hybrides *tritici-agrostidis* ont produit une variété de rouille très semblable quant à ses propriétés pathogènes à l'hybride *tritici-secalis* No. 111 mais moins virulente encore, car toutes les variétés sur lesquelles cette forme a été essayée se sont montrées résistantes. L'agrostide blanche qui est attaquée par la race *agrostidis* est modérément résistante à la rouille hybride tandis que les variétés d'orge sont ou résistantes ou attaquées modérément. La similarité des caractères pathogènes des hybrides *tritici-secalis* et *tritici-agrostidis* porte à croire que des hybrides de ce genre se forment fréquémment entre la race *tritici* et les autres races de *P. graminis.*

L'EFFET DU CHARBON SUR LE DEVELOPPEMENT DE LA ROUILLE ET LA VIGUEUR DE LA PLANTE DANS L'AVOINE. John N. Welsh, Laboratoire fédéral de Recherches sur la Rouille, Winnipeg, Man.

L'auteur a trouvé que les pieds d'avoine attaqués par le charbon sont plus sensibles à la rouille que ceux non attaqués. L'infection par le charbon augmente le nombre de talles non mûres par rapport au nombre de talles mûres et réduit la hauteur des plantes et le rendement. Le charbon causé par *Ustilago levis* semble réduire la hauteur de la plante davantage que le charbon causé par *Ustilago avenae.* Les pieds dont tous les panicules sont infectés par le charbon possèdent moins de talles que les pieds normaux, tandis que ceux partiellement infectés ont autant et quelques fois davantage de talles. Les pieds inoculés avec *U. levis* et *U. avenae* et vraisemblement infectés par le mycélium de ces champignons sans montrer de panicules charbonneux sont intermédiaires quant à la maturité, à la hauteur et au rendement entre les pieds complètement charbonneux et les pieds non inoculés. Dans trois variétés *U. levis* a réduit le tallage dans une plus grande proportion que U. avenae.

CONTROLE DE LA DIARRHEE BLANCHE DES VOLAILLES AU NOUVEAU BRUNSWICK. F. Leslie Wood, Ministère de l'Agriculture du Nouveau Brunswick, Fredericton, N.B.

Des échantillons de sang sont prélévés par des employés du Ministère de l'Agriculture avec l'aide des propriétaires. Ces échantillons sont envoyés au Laboratoire Commercial où leur analyse est faite. La maladie est progressivement

éliminée de la Province. L'amélioration qui a déjà été apportée justifie pleinement les dépenses entreprises.

La Transmission par la Graine des Maladies du Bariolage et de la Mosaique des Tomatoes. G. H. Berkeley et G. O. Madden, Laboratoire fédéral de Pathologie Végétale, Ste Catharines, Ont.

Les auteurs montrent que les maladies du bariolage et de la mosaïque peuvent être transmises par la graine. Pour éviter ces maladies ils recommandent d'utiliser uniquement des graines provenant de plantes saines et de surveiller l'infection par les insectes, le sol ou les facteurs mécaniques. Les auteurs ont réussi a cultiver expérimentalement cinq récoltes successives de tomates sans avoir une seule plante affectée de bariolage ou de mosaïque.

Mutations chez le Pommier. R. C. Palmer et C. C. Strachan, Station Expérimentale Fédérale, Summerland, B.C.

Les auteurs discutent la valeur de nouvelles races des variétés de pommes déjà existantes developpées par la sélection et la propagation de mutations.

Heredite du Caractere et de la Couleur des Barbes dans le Ble a Barbes Lisses. S. J. Sigfusson, Station Expérimentale Fédérale, Brandon, Man.

L'histoire du blé à barbes lisses est discutée en détail. Des lignées pures ont été établies pour étudier l'hérédité de la couleur blanche et noire et du caractère lisse ou rugueux des barbes. La couleur de la barbe paraît due à un seul facteur et héritée dans la proportion de 3 à 1, la couleur noire étant dominante. La rugosité des barbes semblé due à un facteur principal. Il semble qu'il y ait aussi au moins un facteur auxiliaire mais son influence n'est pas suffisante pour donner naissance à des phénotypes nets. Les facteurs déterminant la couleur et le caractère des barbes sont hérités indépendamment. L'examen cytologique n'affirme ni ne confirme la théorie d'un croisement naturel au début de l'histoire de ce blé. Les plantes examinées ont été trouvées normales au point de vue cytologique, possédant 14 chromosomes au stage haploïde. La théorie d'un croisement naturel aussi bien que d'une mutation de gêne est avancée pour expliquer l'origine du caractère lisse des barbes.

DR. H. BARTON, LE NOUVEAU DEPUTE-MINISTRE DE L'AGRICULTURE GENERALEMENT ACCLAME

C'est avec une vive satisfaction que les membres de la C.S.T.A. ont appris la nomination du Dr. H. Barton, doyen un Collège Macdonald, au poste de députéministre de l'agriculture à Ottawa en remplacement du Dr. Grisdale, qui a pris sa retraite il y a quelques mois. C'est avec une entière satisfaction que d'un bout à l'autre du Dominion cette nomination a été accueillie par tous ceux qui s'intéressent à l'agriculture au Canada. Personne cependant plus que les membres de la C.S.T.A. n'est en droit de se féliciter du choix qui a été fait. Déjà le Dr. Grisdale n'avait jamais manqué de manifester son intérêt pour notre association depuis sa fondation en 1920, et en maintes occasions de l'aider par son support moral et financier. Il a de ce fait plus d'un titre à notre reconnaissance. Voilà maintenant que le nouveau député-ministre est un ancien président de l'Association, à la formation de laquelle il a directement contribué. On se rappellera, en effet, que le Dr. Barton, a été vice-président de la C.S.T.A. pendant ses trois premières années d'existence, puis a occupé le poste de président de 1923 à 1925. Il n'y a probablement pas un membre de l'Association qui ne l'ait rencontré en quelque occasion, et, l'ayant rencontré, ne se soit senti attiré vers lui par un puissant courant de sympathie.

C'est qu'en effet le Dr. Barton est bien davantage qu'un des meilleurs techniciens de l'élevage. Il joint à la profondeur de ses connaissances techniques et à la sûreté de son jugement des qualités de simplicité et d'humanité qui lui valent, en plus de l'estime, le dévouement de ceux qui viennent en contact avec lui. Universitaire distingué, ayant la pratique de l'education et de l'administration, il possède en outre le robuste bon sens qui est peut-être la plus grande vertu qu'il soit possible à un homme d'avoir.

Les qualités du Dr. Barton ne seront d'ailleurs nullement superflues dans son nouveau poste. Sur le député-ministre repose la tâche d'assurer à la politique agricole du pays la continuité et la stabilité sans lesquelles les plus belles initiatives n'aboutiraient qu'au gâchis. S'il est vrai, comme le veut André Maurois, que le génie soit l'aptitude à concilier les contraires, un bon député-ministre de l'agriculture a bien besoin d'avoir du génie. Avoir en l'avenir du pays une foi illimitée, mais conserver un esprit critique toujours en éveil qui ne soit dupe d'aucune chimère—penser avec la perfection d'une machine, mais rester humain, tenir compte des sentiments, des émotions, des préjugés même—commander à la fois le respect des savants et la confiance de la foule des cultivateurs anonymes de qui est faite l'agriculture canadienne—voilà ce que le pays est en droit d'attendre de son députéministre de l'agriculture. Il faut féliciter les gouvernants responsables du choix qui a été fait: nul n'est mieux qualifié que le Dr. Barton pour remplir pareil poste. Les diverses provinces ont en lui une confiance absolue. Elle savent qu'il les connait, les comprend, que depuis des années il médite sur leurs problèmes dont il a une conception claire et précise. Cette confiance est l'arme la plus efficace qui puisse être donnée à un homme dans sa position. Ajoutée aux qualités personnelles du Dr. Barton, elle lui permettra de diriger avec efficacité les destinées de l'agriculture canadienne. Sa connaissance directe de la Grande Bretagne et d'autres pays d'Europe lui sera aussi une aide précieuse dans son nouveau poste. Nul doute qu'au cours de discussions entre les puissances de l'Empire ou les nations du monde sa personnalité n'établisse dès l'abord un état d'esprit favorable au Canada.

Le Dr. Barton est un homme que toute association peut s'enorgueillir de compter parmi ses membres et la C.S.T.A. est fière qu'il soit inscrit au nombre de ses anciens présidents. Il voudra bien nous permettre de lui souhaiter ici un plein succès dans la carrière où il s'engage, et de lui offrir l'assurance de la coopération respectueuse et dévouée de tous les membres de notre association.

EASTERN CANADA SOCIETY OF ANIMAL PRODUCTION

PROCEEDINGS AND ABSTRACTS

The fourth Annual General Meeting of the Eastern Canada Society of Animal Production was held on July 5th and 6th at the Chateau Laurier, Ottawa, under the Chairmanship of the President, Prof. J. C. Steckley of the Ontario Agricultural College. The President reviewed the work of the Society and called attention to some problems which are particularly pressing at the present time. In conclusion, he stated:

"The real aim of our Society is to bring our members closer together and to give them a broader vision of the great industry of which we form a part. I believe much has been accomplished in the past six years. We are all better acquainted. We have a much better idea of the work each one is doing than six years ago. We hope this meeting will reach another milestone in advancement."

Hon. Robert Weir, Dominion Minister of Agriculture, in a very practical address outlined some of the improvements which he felt must be made in the animal industry and some ways in which government services could assist in bringing about these improvements. Dr. E. S. Archibald, Director of the Dominion Experimental Farm System, discussed the work of this Branch of the Department of Agriculture.

Routine matters of business, including reports and resolutions, were handled with dispatch. The Secretary-Treasurer reported the finances of the Society in a flourishing condition. The following officers were elected for the ensuing year.

President—J. C. Steckley.
Vice-President—C. L. Bailey.
Maritime Director—W. W. Baird.
Quebec Director—A. Morin.
Ontario Director—W. J. Bell.
Secretary-Treasurer—E. B. Fraser.
Auditors—H. L. Trueman.
R. W. Zavitz.

In addition to the addresses mentioned above, the following papers were delivered during the sessions. Complete copies of these papers may be secured from the Secretary, Mr. E. B. Fraser, Central Experimental Farm, Ottawa.

ECONOMIC RESEARCH IN RELATION TO THE LIVE STOCK INDUSTRY.

J. F. Booth, Agricultural Economics Branch, Department of Agriculture, Ottawa.

In agriculture as well as in other industries there is need of more reliable economic information. Research workers have long realized this inefficiency and have been persistent in their requests for means to increase the supply. There is also an insistent demand from farmers and the public generally for more facts of an economic nature concerning agriculture. To meet this demand the Dominion Goverment and a number of the Provinces have established divisions to engage in economic research.

In order that maximum results may be obtained it is necessary to co-operate, not only with those engaged in economic research elsewhere, but also with those employed in other phases of agricultural work.

The particular field of research that we refer to as "agricultural economics" is not one that has suddenly emerged. For some time other agricultural workers have contributed to the development of this subject. Much of the experimental and research work carried on by animal husbandmen, and by others, was conducted along lines that have since been somewhat more highly developed and co-ordinated by the agricultural economist.

Farm Business Analysis. Among both animal and field husbandmen, as well as in other fields, there have been some who saw the possibility of advantages to be derived from the study of activities of farmers on their own farms. These men recognized the value of statistics and realized that if information concerning farming practices could be obtained from a representative number of farmers the results would be reliable and would check and strengthen conclusions based upon experiments conducted in the field or feed lot.

As this method of analyzing the farm business gained favour men concentrated upon refinement of methods and in time there emerged a group who devoted their entire attention to the study of farming along these lines. Eventually a sphere of study was evolved which dealt with the co-ordination and systematizing of methods, which, for want of a better name, is referred to as "farm management".

Marketing Research. In the same way some men began the study of marketing problems by analyzing the business and management problems of marketing concerns as contrasted with the policy of making "experimental" shipments or of engaging in the actual operation of marketing agencies for the purpose of gaining information. In like manner, rural social problems, credit, taxation, transportation, and similar matters have been subjected to analysis. The classification and analysis of methods employed and results obtained and the application of economic principles to the study of problems in these several fields of endeavour comprises what is known as "agricultural economics". The work of the agricultural economist occupies much the same relationship to animal husbandry in manner of development, method of application, and degree of specialization as does, for example, bacteriology or animal pathology.

It must be recognized, of course, that the economist can only study those problems or matters which are capable of interpretation through statistical measurement. For the most part, they deal with business management—with the relation of input to output as measured in terms of price. Thus, for example, costs of production and the relationships of costs and returns to management and feeding practices may be studied on individual farms.

Similarly, with the co-operation of representative firms engaged in the handling and marketing of live stock and live stock products it is possible to relate costs and returns to management and operating practices so as to determine which methods produce most satisfactory results.

Work Undertaken. Illustrations of economic research undertaken on behalf of the live stock industry may be of interest. They include the following: surveys of the cost of producing milk in Quebec and Saskatchewan by special commissions and in British Columbia and Manitoba by the Agricultural Economics Divisions of the Colleges of Agriculture; determination of a barley-hog ratio and of cycles of live stock production and prices by the Farm Management Department of the University of Saskatchewan; a business analysis of 140 sheep ranches conducted jointly by the Dominion Experimental Farms and Agricultural Economics Branches; an analysis of the cost of horsepower as a part of a business survey of 900 farms in Western Canada by the Canadian Pioneer Problems Committee, the Universities of the prairie Provinces and the Dominion Agricultural Economics Branch; an economic survey of milk marketing in the Sydney-Glace Bay area by the latter Branch in co-operation with the Economics Division of the College at Truro.

These are but a few illustrations of what may be accomplished on behalf of the live stock industry by economic research. The field has hardly been touched however—there is much that the animal husbandman and the agricultural economist can do to develop it.

FACTORS CAUSING VARIATIONS IN MILK AND FAT PRODUCTION.

G. E. Raithby, Ontario Agricultural College, Guelph, Ont.

The morning and evening milk was weighed and tested separately from 27 cows in 1929, 1930 and 1931. A wide variation was found in the butterfat test from milking to milking, with the higher testing breeds showing the greatest variation. Over 70% of the evening tests were higher than the morning, while over 56% of the milk was produced in the morning. Low tests were found throughout the late Winter and Spring months, with high tests predominating from June to November. The first drawn milk tested lower than the last drawn. Extremes from 1.5% to 5.0% were found in this work. Cows milked by quarters showed the highest test and the most milk from the first milked quarters. Slow milking tends to lower the test. One test on the milk of a cow gives very little information on her ability to produce fat. Composite samples throughout the lactation periods give a very accurate estimate of the amount of butterfat produced.

ESTIMATING STATISTICALLY THE SIGNIFICANCE OF DIFFERENCES IN COMPARATIVE FEEDING TRIALS.

E. W. Crampton, Macdonald College, P.Q.

This paper appeared in full in the September, 1932, issue of *Scientific Agriculture* (Vol. XIII, No. 1, pp. 16-25).

COMPARATIVE MEDICINE AND ITS RELATION TO ANIMAL INDUSTRY.

Dr. C. A. Mitchell, Health of Animals Branch, Dominion Department of Agriculture, Ottawa.

Comparative medicine may be defined as that branch of medical science that has to do with the prevention and treatment of diseases of all animals with the exception of man. In addition to this, within the field of comparative medicine fall certain problems of inspection of animal products that are definitely connected with the field of public health.

The first school of comparative medicine was founded in Lyons, France, in 1742, and was followed by an English school in 1791. In both schools entrance requirements were equal to those of the universities of the day. Financial difficulties, however, were the cause of lowering these requirements to secure more students. Similar difficulties forced Andrew Smith, the young Scotchman, who was faced with the task of setting up the first Canadian veterinary college. The type of graduate turned out from this college did little to raise the esteem of the profession in the minds of the agriculturists. Great strides have been made since these earlier times and today we have a high standard of training and service in the veterinary profession.

Unfortunately, remuneration in private practice is not commensurate with the training and service available. Means should be taken to establish good private practitioners in communities where live stock is the principal industry. The animal husbandry profession should encourage this rather than work toward the establishment of gratuitous services which are often of questionable value. The private veterinarians are capable of rendering as splendid a service as any professional body that forms a part of the national life of this country.

CAN WE LEARN ANYTHING FROM A FREE CHOICE OF FEEDS AS EXPRESSED BY CHICKENS?

W. R. Graham, Ontario Agricultural College, Guelph, Ont.

During the past few years there have been some very radical changes in feeds and feeding methods for young and mature stock, particularly with chickens.

More recently some studies have been conducted in reference to the rearing of game birds on a commercial basis.

Most of the changes have been associated with mass rearing and changes due to labour and general economics: so that, not only has the diet changed but also the manner and times of feeding, to say nothing of the influence of breeding. Nearly everybody will agree that general progress for the better has been secured, but with this have come along certain peculiar annoyances such as crooked legs, slipped tendons, some more acute expression of feather pulling, toe picking, etc. With this has come hopper feeding and a tendency to do away with the grass range—possibly better expressed by the wording of 'more birds per acre with less human labour'.

The studies made by most workers in reference to nutritional disturbances leave some points that are not very clear. The writer is not aware of anyone who has yet succeeded in rearing chickens on a purified diet. Until this is done, some problems are very difficult to pin down to one hazard.

The data herewith presented represent five groups of chickens hatched during February, March, April and early May. The chickens were not allowed on the ground or grass range. They could get some direct sunlight. Four of the groups represent over 200 birds to a lot, while the first group consisted of 165 birds. Check lots on ordinary rations were run at the same time. The breeds used in each lot were Barred Plymouth Rocks, White Leghorns, Wyandottes and Rhode Island Reds. Owing to hopper space available, all feeds were not given in each trial, but in general there were over twenty-five different feeds available in each lot.

There is no general expression that the chicks grow faster or have less mortality on a Free Choice Diet. There is a general observation that possibly the chickens on Free Choice Diet are more growthy but not as fleshy. This point would be very difficult to prove.

The most interesting thing is that the February hatched chicks consumed over two pints of cod liver oil to the hundred pounds of feed as compared with one twenty-fourth of a pint of cod liver oil to the hundred pounds of feed consumed by the May chicks. They appear to adust themselves to the hours of sunlight.

None of the chicks on Free Choice Diets had any trouble with crooked legs, slipped tendons, etc. It is rather remarkable that out of a number of over 1,200 birds there was not a single bird with a trouble of this kind.

The Free Choice chickens, on the whole, were much more contented than the check lots, and were much less inclined to feather pulling, with the exception of lot 5 which had no semi-solid buttermilk.

The manner in which feed is prepared, particularly with oats, suggests a vast difference in the palatability of the grain. One might suggest that a chicken does not like any feed finely ground, but these chickens ate freely of hominy which is finely ground.

The low intake of hammer ground oats and alfalfa meal certainly indicates a doubtful method of preparation.

The general results in the consumption of minerals, such as Bone Meal, Oyster Shell and Granite Grit, would lead one to believe that many of us have used too much mineral, and that it might be wiser to place such feeds in hoppers rather than to mix them in a mash.

There is a real interest in the chick's choice of feed containing the germ of the grain, when one considers the influence of germ meal on semi-purified diets and the chick's consumption of germ meal.

In general, the choice of feeds is not marked during the first week or ten days of the chick's life.

LIVE STOCK MARKETING. H. S. Arkell, Canadian Live Stock Co-operative Ltd., Montreal, P.Q.

There is one phase of this broad subject which seems to me of more than ordinary importance at the present time. It is the phase which has to do with the whole question of price. We might, under our general subject, cover a rather wide range of studies, market outlets, market requirements, marketing methods, marketing costs. But these are static, statistical, comprehensible things. All of them may be rounded down, explained, sorted out and agreed upon in our general scheme of live stock marketing. The elusive thing is price. Yet this is the thing that the producer invariably thinks about when he thinks either about markets or marketing. As a matter of fact, unless we can better solve the very vital problem of price, the economic future of agriculture is desperately uncertain. I should like to offer a few comments, therefore, upon some factors which affect the price of our primary commodities.

We have always been somewhat fatalistic in our approach to this question. We have more or less complacently accepted the dictum that the inevitable economic law of supply and demand determines the price we may expect for our products and that is all there is to it. The law of supply and demand operates, it is true, but it operates under conditions that very generally are humanly devised, deliberately so, rather than from natural and unrestricted causes.

Industry under the protection of a tariff has quite consistently been able to command a higher price for its goods on the domestic market than it could obtain on the world market abroad. Put in another way, industry has been able to manage its business such that its surplus, speaking broadly, has not detrimentally affected its price structure at home. It may be added that the current price of labour is equally illustrative of the principle to which I have referred. Unfortunately, this is not the case in the instance of primary commodities and this is particularly true of farm products.

Such a condition produces an inequality between industry and labour on the one hand and agriculture on the other that dangerously destroys the economic balance of our body politic. Is there a remedy for this condition? I sincerely think there is. The key to the whole situation is to be found in the manner in which we handle the export surplus. The remedy is just this—under a nationally directed marketing plan, remove the surplus; sell it on the export market for what it will bring; thereby re-establish the domestic price at normal levels and pay the loss on export by a levy, product by product, against all goods marketed. This is, in effect, the principle of the plan so successfully followed by industry during the past years. With respect to the products of which our export surplus is measurably less than our consumption, I have no hesitation in saying that it can be made to apply equally as well. As is well understood, the plan will of course require government sanction.

There are two great justifying considerations which support the practicability of this plan against almost all argument. The one is that, with respect to a large number of our major products, beef, bacon, butter, eggs, our exportable surplus is pitifully small as compared with what we consume. The other is that a market exists—the British market—which, if properly approached, will welcome and absorb all and more than all that we can offer for sale. Given the confidence of a stabilized price at a reasonable and equitable level such as can be effected under this plan, our farmers will be encouraged to produce to an extent which will again firmly and

profitably re-establish our export trade. Careful standardization and sound salesmanship, together with continuity of supply will enable Canada to secure full recognition for her goods and at prices probably little less than our own. The element of selling hazard will be eliminated, however, and this is the one feature which we need to prevent the demoralization of our markets at home. In the light of all that the approaching Economic Conference suggests and implies, looking to the expansion of inter-Empire trade, it will require a plan such as this to take advantage of the opportunities that the results of this Conference are fully expected to offer. I respectfully suggest that the putting into effect of this plan will go a long way toward putting agriculture in Canada again on its feet.

THE PREVENTION OF ANEMIA IN PIGS. R. G. Knox, Ontario Agricultural College, Guelph, Ont.

Research at the Ontario Agricultural College in connection with the prevention of anemia in winter-born pigs has revealed several interesting facts concerning the influence of this undesirable condition on mortality. The following findings would appear to have considerable significance.

(1) That this condition prevails from the Mason-Dixon line north in America, and that British pigs also suffer from anemia. (2) That the ash of sow's milk is deplorably low in Iron content and that to date no means of influencing the same has been discovered. (3) That there is an apparent storage of Iron in the blood of the new born pig, as indicated by the haemoglobin content, which may vary from 60% to 85%. (4) That this storage is utilized during the first week or 10 days of the pig's life. (5) If the nursing pig can be maintained with a haemoglobin content at even as low as 50% until he is between 4 and 5 weeks old there is a considerable amount of assurance that he will survive and develop. True, he will not develop to the same degree of satisfaction as will the pig which has a higher haemoglobin count. (6) That amongst the mortality, death is not necessarily due directly to the anemic condition itself, but rather in the majority of cases to the invasion of other diseases to which the anemic pig is highly susceptible because of his very low resistance. (7) That the maintenance of a temperature ranging from 55° to 65° F. in the pen is decidedly advantageous. Pigs suffering from anemia cannot withstand exposure to low temperatures. (8) Exposure of the sow during pregnancy, and the sow and litter during the nursing period to the rays of ultra violet light from a mercury quartz lamp, will not control this condition. (9) Exposure to sunlight with access to vegetation and soil is beneficial. (10) Iron Sulphate in the Ferric and granular form fed by mouth at the rate of 20 grains per day per pig will prevent anemia. (11) The provision of sods treated in the following manner would appear to be a satisfactory method of prevention: 1 heaping teaspoonful of Iron Sulphate added to 1 quart of water and poured over 1 square foot of sod on the earthern side, allowing 1 square foot of sod per pig twice per week, the sod to be placed in a creep or crate for purposes of protection against the feeding of the mother sow on same. This latter method has been tried only one winter. The results, however, are very satisfactory. (12) The age at which Iron can be administered to a pig with any degree of safety is somewhere between a week and 10 days.

CURRENT PUBLICATIONS

THE AGRICULTURAL SITUATION IN 1930-31. International Institute of Agriculture, Rome.

"The Agricultural Situation" serves as an Economic Commentary to the International Yearbook of Agricultural Statistics for the same year, and following the general plan of "The Agricultural Crisis" furnishes another valuable contribution to the systematic study of agricultural economy during this critical period.

Figures are presented showing changes that have taken place in gold reserves, in the rates of discount, in the note circulation and the wholesale price indices of twelve countries. From examination and study of these data they conclude that the influence of the movements of gold, as well as changes in credit conditions and the volume of note circulation played only a secondary part in the depression, this being caused in the main by factors other than monetary. The monetary movements themselves are regarded as results of a series of independent causes responsible for the want of balance in the world economy.

> The state of world economy before the war is described as, "a system of free exchange of the factors of production—enterprise, capital and labour—as well as of the products, qualified by comparatively moderate customs duties, sufficient to protect the most important national industries, and by treaties of commerce regulating the economic relations of particular States. Though not a system of free trade in the theoretical and abstract sense in which the expression is used by the liberal school, this system, generally speaking, allowed the productive forces to flow towards the most remunerative employment, thus assuring to world economy a return perpetually tending to the maximum".
>
> "The war not only shook this equilibrium, but had economic and political consequences that rendered its re-establishment extremely difficult and led, by a gradual development, to the present crisis."

Attention is drawn to the dissolution of the large single markets of the Old World into detached parts thus severing the secular relations of millions of producers and consumers.

Monetary disorganization following the war exercised a profound influence on the currents of international trade. Stabilization was usually carried out with more regard to financial than to economic consequences and in many cases brought about new complications as it established more or less artificial levels of national prices. Customs tariffs, import duties and other measures intended to maintain the exchanges were increased under the influence of the economic nationalism which characterises the present epoch and the trade in produce became more than ever hindered. Some countries were compelled to sell more or less at any price to obtain money that was required when payments became due. This increased the disorder in the markets and pushed prices, already depressed, still lower. On the other hand trade in produce being hindered, the use of metal in settling international accounts acquired exaggerated proportions.

> "The movements of gold and its concentration are thus the effect, on the one hand, of the financial charges imposed since the war on certain countries in favour of others, and, on the other hand, of the development of protectionism and of the economic particularism which prevents the circulation of produce."

Efforts of single nations, even the most important exporting countries, to check the fall in prices on the world market and to stabilize them are futile. Agreement must be made with other exporting countries which will bring about concerted action.

Modern protectionism, the authors state has no longer the character of a moderate safeguard. It is not only in the height of the barriers which it sets up against international trade that protectionism of today differs from pre-war pro-

tectionism; it is also in the increase in the number of these barriers and in the splitting up of the great unitary markets of Europe.

In addition to the chapter reviewed on "The Development of the Agricultural Crisis" the volume contains the following five chapters:

(2) Notes on Market Conditions.
(3) International Action in Connection with Agriculture.
(4) Government Measures of Farm Relief.
(5) Action Taken by Voluntary Organisations in the Interests of the Producers.
(6) The Economic Conditions of Agriculture.

—A. E. Richards.

FERTILIZERS AND FOOD PRODUCTION ON ARABLE AND GRASS LAND. Sir Frederick Keeble, C.B.E., Sc.D., F.R.S., with a Preface by Sir Harry McGowan, K.B.E. Published by Oxford University Press, London and Toronto. Price $1.50.

This latest published volume by Sir Frederick Keeble is a most valued contribution to modern literature on agricultural science. While scientific, the subject is treated by the author skillfully and lucidly in a very practical way, and conclusions drawn are ably supported by data derived from numerous investigations conducted by the author and his co-workers, as well as by other leaders in research. Sir Frederick, who is director of the Agricultural Research Department of Imperial Chemicals Limited, was formerly Professor of Botany at Cambridge University.

The book, dealing with the past and present status of agriculture, is wide in its scope, and the principles which it expounds are applicable wherever agriculture is practised. It is highly commended as a text book for teachers and students in agriculture, and no less for the practical agriculturist who desires to extend his knowledge of how crops grow and feed.

On page 43 of "*Fertilizers and Food Production*" a chart shows graphically the relative food values (1) Intensive Pasture Grass, (2) Oat Crop and (3) Ordinary Grass cut for Hay. The author remarks: "Grass land, as it is, is the inferior of arable land as a producer of food . . . As Chart III shows, grass supplied plentifully with nitrogen and mineral food yields more than double the amount of crude protein, nearly treble the digestible protein, about a third more total food measured as starch, and stores of energy one-third more than are contained in the oat crop . . . Grass land is now seen to be not the inferior but the superior of arable (cultivated) land in capacity for food production . . . In New Zealand . . . there are already 3,000 farmers—expert graziers all of them—who are applying nitrogen and phosphatic fertilizers to their grass land . . . Pastures were dressed with mineral fertilizers in the autumn or winter and with nitrogen in the early months of the year . . .

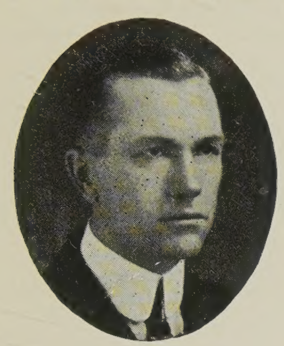
Our readers, or many of them, are already familiar with the term, "Early Bite", as applied to the first grass of spring urged forward by an application of nitrogenous fertilizers. On Pages 47-50 of his book, Sir Frederick discusses this important feature of pasture management and records the results of experiments, as follows: "Early Bite Trials, numbering 492, were made in different parts of the country in the years 1929 and 1930 . . . In 447 cases (91 per cent) the grass was ready for grazing from 14 to 28 days earlier on the nitrogen plots".

Continuing, Sir Frederick Keeble says: "Knowledge of the way to get an early bite is becoming general among farmers, and the area of pasture which is treated with nitrogen fertilizer in the spring is increasing year by year. The advantages to the farmer are clear; given suitable weather he can turn his livestock out a fortnight or more earlier, and by letting them graze, save the cost of expensive concentrated foods with which otherwise he must feed them, and he can also put the labour required for the care of the indoor animals to other uses on the farm".

—B. L. Emslie.

DEAN H. BARTON BECOMES DOMINION DEPUTY MINISTER OF AGRICULTURE

The announcement of the appointment of Dean H. Barton of Macdonald College as Deputy Minister of Agriculture for Canada has been received with satisfaction throughout the Dominion. Dean Barton brings to the position qualities that are particularly valuable at the present time. A sound understanding of a wide range of agricultural problems and an ability to direct the machinery attacking these problems are both essential in a Deputy Minister. Dean Barton has the knowledge and has the confidence of a large proportion of the leading farmers in Canada. He has also the close friendship and confidence of the technical agriculturists. Such a combination will go far. He will be more than the Deputy Minister of his own Department; he will be the acknowledged and respected leader of the agricultural services of the Dominion.



While he is known mainly to farmers through his work as an animal husbandman with an enviable reputation as a judge of live stock at leading Canadian and Old Country shows, Dr. Barton is also a keen student of the economics of agriculture. As Dean of the Faculty of Agriculture of McGill University he has had valuable experience in administration, and under his guidance Macdonald College has continually widened its influence on the agriculture of Eastern Canada from the standpoint of the development of both research and extension.

Dr. Barton's qualifications as an administrator of technical services do not rest alone on his achievements at his own institution. He has for some time been developing a national viewpoint on agriculture. Before he became Dean at Macdonald he was elected Vice-President of the Canadian Society of Technical Agriculturists and served in this capacity for the first three years of the Society's existence. He served as President from 1923-25. These first five years were the hard years, and Dr. Barton had ample opportunity to become acquainted with the magnitude of the task undertaken by the Society. An idea of his sane viewpoint and sound judgment on problems relating to agricultural services may be gathered from his Presidential Address to the C.S.T.A. in 1925.

> "In the past twenty years, professional agriculture in Canada has had uninterrupted growth; the Dominion Department of Agriculture has grown enormously, the Provincial Departments of Agriculture have been created in their present form, colleges have sprung up in numbers, agencies and positions have multiplied more than tenfold and expenditure has mounted correspondingly and in accordance with the decreased value of money. Agricultural education has been broadcast and the profession has prospered. In our course of exploration we covered ground at a rapid pace and the going was fairly smooth and easy. How is it with us now? We are still broadcasting but it is apparent that progress is more difficult, conditions seem more adverse, the yield is smaller and the cost is high, so people within and without the profession are asking us questions and making comments. Our policies and our methods have been successful in the past but it is suggested that we are too loathe to make any drastic changes in them. Adjustments of course are made but is it a fact that we are too much inclined to tread the beaten trail? . . . We find ourselves committed to certain types of organization which have met the requirements in the past and from which it is difficult to depart. Our plans of operation, however, need not be so fixed; we ought at least to examine them critically in relation to situations that obtain, and above all our mental attitude collectively and individually should be such that no possibility will be ignored. Let us not be afraid to measure ourselves with this yard stick. The position of agriculture demands it and can afford nothing else.

In the past our major effort has been directed with a view to helping the farmer take advantage of what opportunity there was. As a rule we found it easy to help him, and first aid work was simple; we found him receptive and even curious; he was in need of simple help and the idea was new. Today the case is somewhat different; he needs help because he is in greater difficulty but his trouble is harder to treat. The factor of cost is more serious, the farmer himself is more able to do his own first aid work and has reason to expect a more highly skilled service from us. In relation to our work, both farm and farmer have shifted positions and I am not at all sure that professional agriculture has sufficiently oriented itself accordingly.

Our function is a twofold one, the establishing of knowledge and the humanizing of it. Naturally as our problems become more intricate our methods must become more thorough, more systematic, more technical, and more scientific. The technical and the scientific in agriculture are far from being explored. There has not been time, money, nor men so we have used what we had and what we could borrow with the result that there has been considerable fallacious teaching and many things are still baffling us.

We are hearing more and more about highly trained men and scientific work. That is a good omen. These are the keys with which we must unlock much of the information we need, but let us not forget the fact that an accumulation of blank keys will not serve our purpose. It is necessary that they unlock something. We must not become impatient but I am sure we all want to feel that the scientific and technical work carried on in the name of agriculture are really coming to grips with the issues over which we now seem to be stumbling. Whether rightly or wrongly there is some impression abroad that among those whose work carries this responsibility, there are some who seem content to feel that training and science may be recognized as the end and not the means. Wisely enough we have been adding to our equipment for better work but not a few contend that through this ambition for higher standards, agricultural education in general has suffered.

Much as we need more vital information we are already equipped with an appalling mass and while our efforts in dissemination have been noteworthy as is evidenced by the changed position of farms and farmers, it must be amazing to everyone that there is still such a wide divergence between knowledge and practice. Everyone must realize that despite imperfections any considerable application of what is available would change the whole aspect of farming. Is it the farmer or his so-called instructor who is to blame? Obviously the answer could be argued both ways but the burden of proof rests upon us and after all we must take farmers as we find them."

We feel that Dr. Barton comes to the leading positon in the field of technical agriculture at a time when the situation is far more pressing than it was in 1925. So far as we know he has not changed his opinions. In the recent National Conference on Agricultural Services in Toronto he took essentially the same stand. There is no doubt that a thorough examination into the relationships between the various agencies serving agriculture is needed. The machinery for that examination and for the correction of some of our faults was set up at the Toronto Conference. Upon the Dominion Department of Agriculture rests the responsibility of fulfilling its national status by taking the lead in putting this machinery into action. Provincial and institutional agencies are sympathetic; the times are ripe; the man for the task is appointed; let us proceed.

C.S.T.A. DIRECTORS' MEETING

The annual winter meeting of the Directors of the C.S.T.A. will be held in the Club Room of the Royal York Hotel at 2.00 p.m. on Friday afternoon, November 18th. A considerable amount of important business will be transacted. Members having any resolutions to lay before the Board of Directors should forward them at once to the General Secretary, 306 Victoria Building, Ottawa. Following the meeting the annual C.S.T.A.-O.A.C. alumni banquet will be held.

CONCERNING THE C.S.T.A.

IMPROVEMENTS IN *SCIENTIFIC AGRICULTURE*

Favourable comment has been received on the improvements which have been made in the form of the official journal of the C.S.T.A. While the changes made in accordance with the recommendations of the Publications Committee have not been extensive, the quality of the magazine has been improved and the cost lowered. The change to a less glossy paper eliminates a certain amount of eye strain, and reduces the cost of printing approximately three hundred dollars per year. This paper is satisfactory for the majority of illustrations, and arrangements have been made to insert a limited number of special cuts on a highly finished paper at no increased cost.

A limit has been put on the length of articles and this has already had a salutary effect. In cases where articles exceed twelve pages in length a considerable portion of the cost of the extra pages is recovered. The majority of articles awaiting publication are well under the twelve pages, however. This permits more variety in the contents of the journal. In the first three numbers of the current volume we have published eighteen articles as against thirteen last year. Institutions which desire early publication of acceptable articles may secure the same by paying the full cost of publication.

There is also a considerable increase of material in the back section of the magazine. The use of smaller type allows the inclusion of about twenty-five per cent more material per page than was printed previous to volume twelve. It will be the policy to include as many reviews of books and bulletins as possible. Series of abstracts of papers read before affiliated groups will be printed. Those read before the last Soils Group meeting were included in the October issue, and those read before the Eastern Canada Society of Animal Production are included in the present issue; others will follow. For the convenience of the French members and of European subscribers we will continue to provide French abstracts of the main papers in each issue in addition to original French articles.

News items concerning members are desired, and will be published as rapidly as possible. It is not possible to give detailed accounts of the activities of each local, but items of Dominion-wide interest will be given from time to time. Activities of the Society in connection with the co-ordination of agricultural services will be reported during the next few months.

NOTES AND NEWS

F. H. Peto, (Manitoba '28) formerly located at Edmonton, Alberta, is now occupying the position of Research Assistant, Associate Committee on Grain Research, at the National Research Laboratories, Ottawa.

Erdman Braun, (Manitoba '28) formerly at the Dominion Experimental Farm, Morden, Man., is now engaged in post-graduate work at the University of Minnesota, University Farm, St. Paul, in the Division of Entomology and Economic Zoology.

N. S. Golding, (Toronto '14) formerly Associate Professor of Dairying at the University of British Columbia, has accepted the post of Acting Associate Professor of Dairy Husbandry at the Washington State College, Pullman, Washington.

D. C. McKenzie, (British Columbia '29) recently secretary of the British Columbia Jersey Breeders' Association, has been admitted to the Graduate School of the University of Aberdeen, Scotland. He intends to carry on research work

at the Rowett Institute for Research in animal nutrition under Dr. J. B. Orr and Dr. J. J. R. McLeod.

F. W. Grauer, (British Columbia '30) is attending McGill University taking a medical course.

H. W. Lohse, (Copenhagen '25) is continuing his research work in the Departments of Chemistry and Physics at the University of Toronto.

Maurice St. Pierre, (Laval '31) is taking his second year of post-graduate work at Cornell University and is located at 305 Oak Ave., Ithaca, N.Y.

F. B. Hutt, (Toronto '23) Professor of Animal Genetics at the University of Minnesota has been elected President of the American Poultry Science Association for the year 1932-1933.

Z. Perlman, (Manitoba '30) has left on a trip to Great Britain and Continental Europe.

F. Godbout, (Laval '25) Plant Pathologist, Quebec Department of Agriculture, has changed his address to 152 rue Notre Dame Est, Chambre 44, Montreal.

W. J. Cowie, (Toronto '31) formerly of 314 Albert Ave., Saskatoon, Sask., is now taking post-graduate work in Economics at Aberystwyth, Wales. His mailing address is West Grove, Menthyr Tydfil, South Wales.

T. G. Rayner, (Toronto '89) District Seed and Feed Inspector for Northern Ontario, Eastern Ontario and Western Quebec, has superannuated from the Federal Service. Mr. Rayner has been on the staff of the Dominion Seed Branch since 1905. Members of the Branch presented Mr. Rayner with a gold watch and an illuminated address, and gave Mrs. Rayner a silver tray. Mr. and Mrs. Rayner will continue to reside in Ottawa.

Paul Langlois, (Laval '20) Sheep and Swine Promoter, Dominion Live Stock Branch, Murray Bay, is now located at Rimouski.

W. Southworth, (Toronto '12) who has been studying at Aberystwyth, Wales, is now at the Rothamstead Experimental Station, Harpenden, Herts, England.

C. M. Dickey, (Toronto '20) representative of the International Harvester Company, has moved from Summerside, P.E.I., to Kentville, N.S.

R. D. Sinclair, (Alberta '18) Associate Professor of Animal Husbandry, University of Alberta, Edmonton, has been awarded his Ph.D. degree by the University of Aberdeen, Scotland. Dr. Sinclair, who held one of the T. Eaton Scholarships, did research work in swine nutrition, and his paper "The Rôle of Vitamin D in the Nutrition of the Pig" will be published in *Scientific Agriculture* during the winter.

JOINT C.S.T.A.-O.A.C. ALUMNI BANQUET AT ROYAL WINTER FAIR

The annual joint C.S.T.A.-Ontario O.A.C. Alumni Association banquet will be held at the Royal York Hotel on Friday evening, November 18th, at 6.30 p.m. The speaker of the evening will be the Honourable Manning W. Doherty, formerly Minister of Agriculture for the Province of Ontario. His subject will be, "Where do we go from here?" Those who recall the Honourable Mr. Doherty's enthusiasm and driving force during his career as Minister in the Farmer Government will look forward with pleasure to an interesting address. Dean H. Barton, newly appointed Deputy Minister of Agriculture for Canada, will be the guest of honour. There will be a considerable representation of Ontario O.A.C. men and O.A.C. and C.S.T.A. men from other institutions. These banquets have always been enjoyable occasions and all who can possibly arrange to be present will have a chance to renew many old acquaintanceships. The exact location of the banquet in the Royal York Hotel will be shown on the notice board and tickets will be on sale at the door at $1.50 each.